GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2072

REVISED EPICENTRES FOR EARTHQUAKES IN THE LOWER ST. LAWRENCE SEISMIC ZONE, 1928-1968

John Adams, Jennifer Sharp, Kimberly Connors

Geophysics Division
Geological Survey of Canada
1 Observatory Crescent
Ottawa K1A 0Y3
Canada

Engineering Cooperative Student, The Division of Co-ordination
Memorial University of Newfoundland, St. John's, Newfoundland

1989

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

Canada

GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2072

REVISED EPICENTRES FOR EARTHQUAKES IN THE LOWER ST. LAWRENCE SEISMIC ZONE, 1928-1968

John Adams, Jennifer Sharp, Kimberly Connors

Geophysics Division
Geological Survey of Canada
1 Observatory Crescent
Ottawa K1A 0Y3
Canada

Engineering Cooperative Student, The Division of Co-ordination
Memorial University of Newfoundland, St. John's, Newfoundland

82 pages including 11 figures

April, 1989

ABSTRACT

Phase arrival times of 46 Lower St. Lawrence earthquakes (m_N 2.2 to 4.8) between 1928 and 1968 were re-examined to test the hypothesis that many of the early epicentres previously placed on land were mislocations of earthquakes that had actually occurred beneath the St. Lawrence River within the active zone defined by recent, better-located earthquakes. The magnitudes of the earthquakes were also revised.

Where possible, the original seismograms were re-read and new data added. Difficulties encountered when relocating these earthquakes included weak signals due to low seismograph gain, incompletely annotated seismograms, uncertain time corrections, and poor station distribution with respect to the seismic zone.

Of the 46 earthquakes, one was found to be a mislocated New Brunswick event, one a mislocated Québec City event, four remained on the Gaspé Peninsula, six remained associated with the Manic-2 reservoir, six lie at least 10 km inland from the north shore, and 28 were found to lie under or within 10 km of the St. Lawrence River. The median distance moved was 35 km and many of the earthquakes moved along the northwest-southeast axis because of the poor station control in this direction. Increasing the Lg velocity to 3.62 km/s removed a 10 km bias from some of the early epicentres. The study confirmed the hypothesis that most earthquakes in the Lower St. Lawrence lie under the river, that both north and south shores have lower levels of seismicity, and that the boundaries of the seismic source zone for the Lower St. Lawrence should be redefined.

RÉSUMÉ

Les temps d'arrivée de diverses phases de 46 tremblements de terre du Bas-Saint-Laurent (mN 2.2 à 4.8) de la période 1928-1968 ont été réexaminés afin de vérifier l'hypothèse que plusieurs des séismes anciens localisés sur terre s'étaient en fait produits sous le fleuve Saint-Laurent à l'intérieur de la zone définie par les événements plus récents et donc mieux localisés. Les magnitudes des séismes ont aussi été révisées.

Dans la mesure du possible, les séismogrammes originaux ont été relus et de nouvelles données ajoutées. Des difficultés rencontrées pour la relocalisation ont été la faiblesse du signal liée à la faible amplification du séismographe, les séismogrammes mal identifiés, des corrections de temps imprécises, et une mauvaise distribution de stations par rapport à la zone séismique.

Parmi les 46 tremblements de terre, un représentait en fait un séisme du Nouveau-Brunswick, un de la ville de Québec, quatre de la Gaspésie, six du réservoir de Manic 2, six à au moins 10 km à l'intérieur des terres sur la Côte Nord, et 28 sous ou à l'intérieur de 10 km du Saint-Laurent. La médiane de la distance de relocalisation a été de 35 km et plusieurs des séismes ont été relocalisés le long d'un axe nord-ouest-sud-est dû à la distribution déficiente dans cette direction. L'utilisation d'une vitesse plus grande (3.62 km/s) pour les ondes Lg a enlevé un biais systématique de 10 km pour certains séismes anciens. L'étude a confirmé que la majorité des séismes du Bas-Saint-Laurent se produisent sous le fleuve, que les rives nord et sud ont toutes deux une séismicité plus faible, et que les frontières de la zone séismique du Bas-Saint-Laurent devraient être redéfinies.

TABLE OF CONTENTS

INTRODUCTION

The Lower St. Lawrence Seismic Zone (Basham et al., 1982) is a region of moderate seismicity under the St. Lawrence River between Baie-Comeau and Sept-Îles on the north shore, and Matane and Mont-Louis on the south (see Fig. 1). Although the zone is moderately active, most of the historical earthquakes have been small, none larger than magnitude five. The geological and geophysical features that control the seismicity of the zone are not as well known as those of some other seismic zones in eastern Canada. Stagg (1986) and Adams and Basham (1989) suggest that the majority of these earthquakes result from thrust faulting on reactivated Paleozoic rift faults that lie under the St. Lawrence River.

Improving the location of the older earthquakes from the Lower St. Lawrence should lead to a better understanding of the zone's seismicity and a better evaluation of its seismic hazard. This is important in determining the seismic design levels used in the National Building Code of Canada and other similar codes that will apply to future development in the Lower St. Lawrence.

Recent earthquakes in the Lower St. Lawrence Seismic Zone (LSL) have been confined mainly to the river itself (see Figs 2 and 3), a much narrower zone than indicated by maps showing all early earthquakes. Many older earthquakes were originally located on the Gaspé Peninsula and the north shore of the St. Lawrence River (see Fig. 4). As will be discussed, the older earthquakes with instrumental records were often poorly located because of inadequate station coverage, poor distribution of stations relative to the seismic zone, and sparse data, permitting an element of freedom in determining the epicentre. Earthquakes that occurred before instrumental readings were available (shown on the map in Smith (1962), and not on Fig. 4) were located by felt reports, and epicentres were therefore commonly assigned to localities on land. In the Lower St. Lawrence Zone, felt reports were often obtained only from the north shore or only from the Gaspé Peninsula, but not from both. Therefore, epicentres tended to be assigned to north or south shore of the river, but not under it. When the first instrumental data became available, they were not very conclusive, and the scatter of epicentres onto the north and south shores, leaving the river relatively aseismic (Fig. 4), suggests a bias toward onland sites. Typical uncertainties given by Smith (1966) of $\pm\frac{1}{2}$ to 1° (see also notes in the pik files of Appendix E) in these epicentres means that he considered that the earthquakes could in fact have occurred under the river. In this report we test the hypothesis that almost all of the 1928-1968 earthquakes previously located on land were mislocated and actually occurred under the river.

The "early-instrumental" earthquakes, recorded by seismographs between 1928 and 1968, were located primarily by graphical methods, and for some of the early earthquakes in eastern Canada the epicentres assigned were approximate. Since the introduction of computerized locations, some work has been done to reassess the epicentres and magnitudes of the early instrumentally-located earthquakes in other parts of eastern Canada, particularly if there was reason to believe that they might have been mislocated (eg. Stevens, 1980b, Adams and Staveley, 1985).

The present report includes the results of three student work reports. Sharp (1987) re-read all the available seismograms and relocated 14 of the larger and better documented Lower St. Lawrence earthquakes. Vatcher (1987) re-read all the available seismograms and relocated the 6 earthquakes that occurred in 1966 under the Manic-2 reservoir. Connors (1988) relocated 26 of the remaining twenty-nine 1928-1968 earthquakes in the Lower St. Lawrence study area, the exceptions being three 1968 earthquakes that were of magnitude <3. Because her earthquakes were smaller ($M \leq 4.2$), fewer data could be gathered from weak phases on the low-gain seismographs of the day, and therefore obtaining good relocations was difficult. Only selected seismograms were re-read to add or confirm arrival times for Connors' earthquakes.

EARLY EARTHQUAKE MONITORING IN EASTERN CANADA

The first recording of a Canadian earthquake was made in Montréal on March 23, 1897, though seismograph operations in Montréal were subsequently discontinued. In the next two decades seismograph stations were established at Toronto, Victoria, Ottawa (OTT), Saint Boniface, Halifax (HAL), and Saskatoon, chiefly to record large distant (teleseismic) earthquakes (Fig. 5; Stevens, 1980a).

Following the 1925 magnitude 7 earthquake in Charlevoix, Québec, two additional stations – Shawinigan Falls (SHF) and Seven Falls (SFA) – were set up in 1927 to record local earthquakes in the St. Lawrence valley. These stations were privately owned by the Shawinigan Water and Power Company who were concerned about possible earthquake hazard to their hydroelectric generating sites. The seismograms were donated to the Dominion Observatory, Ottawa for evaluation. In 1939, a short-period seismometer was installed at Kirkland Lake (KLC), Ontario to monitor rockbursts in the gold mines. Station abbreviations are listed in Appendix A.

Problems in using early seismograph records

Prior to the computer era, earthquakes were located by graphical methods (trilateration) using data from paper seismograms. All of the seismograms studied here were recorded photographically in a process that records a 24-hour record of ground motion plus a time scale as a continuous spiral on a cylinder of light-sensitive paper that is subsequently unrolled. Low seismograph gain and high background noise often made these records difficult to read; the incomplete annotation of some seismograms have made their accurate interpretation difficult.

Clocks were not as accurate as they are today, and significant time corrections were necessary. Accurate timing was necessary to combine data from different stations, and the time correction needed to be known to about ± 1 s. The only method of determining the time correction was by using a daily radio time signal (either from the CBC one o'clock radio time signal or from short-wave CHU); however sometimes the recorded signal was noisy due to weak radio reception, or inadequate because the recording of the time signal on the seismograph was too short. Some station clocks lost or gained time very rapidly, occasionally up to 2 minutes per day (see Appendix B). In many cases the time correction at the time of the earthquake could be very different from that when the radio time signal was recorded. In these cases, the time correction must be calculated by interpolation assuming a linear drift, which was not necessarily the case. Ottawa, being an astronomical observatory, always had accurate time.

Power fluctuations created a variation in the rotational speed of the drums on which the seismograph traces were recorded. This meant that equal distances on the seismogram did not always correspond to the same amount of time. Therefore the minute marks are essential to making accurate measurements on the records.

One inconsistency was in setting the minute marks on the seismogram. The timing on some seismograms was established so that the end of the minute mark marked the start of the current minute (ECM), and on others so that the beginning of the minute mark indicated the start of the current minute (BCM). Prior to 1960, most Canadian seismograms were read ECM, after 1960 they were read BCM (Hodgson, 1961, p. 15). Kirkland Lake, however, was read BCM as early as 1953. Since the minute marks could be as long as one to three seconds, uncertainty concerning the procedure could have a significant consequence for the recalculated epicentre.

Problems arising from inadequate station coverage

One of the main problems encountered by seismologists locating earthquakes in Canada prior to 1970 was inadequate station coverage. The number of stations was few and their geographic distribution was poor relative to the distribution of the earthquakes. For the Lower St. Lawrence, all stations often lay in the same azimuth, southwest up the river. The installation of Shawinigan Falls and Seven Falls in 1927 improved the monitoring of local earthquakes in the St. Lawrence Valley. These two stations had higher gain, faster paper speed (hence better time resolution), and shorter seismometer period than other stations in eastern Canada at the time.

For many earthquakes in the 1940's and early 1950's the key Canadian stations were Seven Falls, Shawinigan Falls, and Ottawa (Fig. 5). Although Halifax began operating a Mainka in 1915, and a Bosch in 1938 (Stevens, 1980a), these were both long-period seismometers with very low gain (magnification $\approx$ 125) and did not record small earthquakes at large distances. The network was significantly improved when a short-period Benioff seismometer was installed in 1937 at Ottawa, and in 1952 at Halifax.

The problem of station control was particularly crucial in the St. Lawrence Valley. Seven Falls, Shawinigan Falls, and Ottawa are all roughly on the same azimuth from the Lower St. Lawrence seismic zone, and so their arcs were almost tangential and did not provide good intersection points when using the trilateration method. (This problem remains even with the computer solutions). Data from the seismographs to the south in the United States such as Fordham (FOR), or Weston (WES) were therefore often very helpful in determining a reliable epicentre. The station distribution was further improved by the installation of seismographs at Schefferville (SCH) in 1962, and at Sept-Îles (SIC) in 1963.

Between 1975 and 1981 several digital stations of the Eastern Canada Telemetered Network (ECTN) were installed within 50 to 100 km of the Lower St. Lawrence Seismic Zone. In particular, epicentre determinations were greatly improved in October 1981 with the installation of a digital seismometer at Grosses-Roches (GSQ) and later at Hauterive (HTQ) in April 1982.

METHODS

Re-determining epicentres

The most common phases used in epicentre calculations are Pg, Pn, Sg, Sn, and Lg. The Pg and Sg phases are assumed to travel directly from the hypocentre to the station, whereas the Pn and Sn phases travel downwards through the earth's crust, are critically refracted along the crust-mantle boundary, and then travel upwards towards the station.

Knowing the velocity of the different phases, the time difference between any two phases can be used to determine the distance from the recording station to the epicentre and also the origin time of the event. Charts showing the travel times of these phases through the earth as a function of epicentral distance were sometimes used to distinguish one phase from another on the seismogram.

By calculating the distance from three or more stations and drawing arcs, the epicentre can be determined by trilateration. In pre-computer years the arcs were literally drawn on a map. These arcs did not always intersect at one clear point, and often a judgment had to be made to decide upon the best intersection point. Computerized methods for analysing the phase data have made epicentre calculations quicker and more consistent because all data can be adjusted together, rather than station by station. A seismologist's judgment is still needed for assigning weights to the phases and interpreting the results obtained from limited data. Where data are good, the graphical and computer methods give very similar epicentres.

Several data sources were available depending on the year of the earthquake. Before 1961, phase arrival times were taken from the Canadian Network Bulletins and written onto epicentre cards (see examples in Appendix C). Later, additional times were added and phases re-interpreted in a different script (in red pencil on the original cards) by Canadian seismologist W. E. T. Smith, who then relocated some of the earthquakes. We found that his re-evaluated phase arrival times were generally very good. Many emergent phases were originally read on the seismograms by E. A. Hodgson (and others), and where these did not fit as Pn, Pg, Sn or Sg phases we have ignored them, as did Smith. In a few cases our re-reading of the records led to the arrival times being changed, or phases re-interpreted. For several earthquakes, some or all of the old seismograms were missing or unavailable, in which case the old data could not be checked and we have assumed them to be correct based on our experience with Smith's readings. Neither Smith nor E. A. Hodgson had at their disposal computer location programs, so their locations were done by graphical methods.

In 1964 a computer program was written to calculate the origin time and the distance from a station to the epicentre using S - P times, which were punched onto computer cards. The epicentre was then determined by drawing arcs on a map. It was first applied to the 1966 data. For the earthquakes between 1964 and 1968 that we relocated, we used phases taken from these computer cards. In 1970 R. J. Wetmiller wrote a program (CANSESS) to calculate the earthquake epicentres. Starting with the data for 1968, eastern Canadian earthquakes were routinely computer-calculated (but it was not until 1972 that western earthquakes were similarly calculated). The computer epicentre location program has been modified from time to time as velocity models and magnitude equations were improved.

The Northeastern Seismological Association (NESA) Bulletin, the Bureau Central International de Séismologie (BCIS) seismological bulletin, and the International Seismological Summary (ISS) were also used to add phases from U. S. stations and confirm U. S. phases taken from hand-written notes on Smith's cards. For a few earthquakes, phases from WES were found and added by asking the station operator to examine their old records.

Depths for most of the earthquakes were fixed at 18 km, half the crustal thickness. This is the standard fixed depth assumed for eastern Canadian earthquakes, and seems appropriate for the Lower St. Lawrence Seismic Zone where the few earthquakes with well-determined depths are at 15 to 20 km (Stagg, 1986; Adams et al., 1988). Earthquakes associated with the Manic-2 reservoir were pegged at 2 km, a more typical depth for induced earthquakes, and the 1968 event near Sept-Îles was assigned a depth of 0 km, as is discussed later.

Earthquakes in this report were relocated by entering the data into the present epicentre location program, 'LOC', used routinely in the Geophysics Division. The LOC program calculates the epicentre and magnitude of an earthquake using the measured phase times, amplitudes and station parameters. Travel times are calculated using a two-layer velocity model (a 36-km thick crust overlying mantle). The following travel time equations use P and S velocities of 6.2 and 3.62 km/s in the crust and 8.2 and 4.7 km/s in the mantle to determine distance from the hypocentre and origin time at each station:

$$P_g - H = \frac{\Delta}{6.20}$$

$$L_g - H = \frac{\Delta}{3.62}$$

$$P_n - H = \frac{\Delta}{8.20} + 5.6$$

$$S_n - H = \frac{\Delta}{4.70} + 9.84$$

where H is the origin time, and Δ is the distance from the hypocentre to the station, and the depth is arbitrarily fixed at 18 km.

Connors and Adams (1988) used the routinely-read Lg phase arrival times from ten recent Lower St. Lawrence earthquakes to determine the group velocity of the Lg phase. They found that the "standard" shield Lg velocity of 3.57 km/s was too slow and derived a mean velocity of 3.624 $\pm$0.006 km/s from 104 individual velocities. Similar high Lg velocities were found by Stevens (1980b, p. 550) who found that the observed Lg velocities for a 1976 Charlevoix earthquake were 0.05 km/s higher than the standard velocity (i.e. 3.62 km/s), by Wetmiller and Cajka (1989) who studied accurately-timed surface blasts and found 3.65 km/s for the northern Ontario shield, and by Woodgold (1988) who studied very long paths from shield earthquakes and found an Lg velocity of 3.62 km/s for the eastern Canadian Shield.

For a station 700 km from the epicentre, the travel time of the Lg phase using a velocity of 3.62 km/s would be approximately 3 seconds shorter than the Lg travel time using the 3.57 km/s model. This bias of 3 seconds represents an epicentral bias in location of 10 km. To demonstate the difference the new velocity has made, 20 Lower St. Lawrence earthquakes previously relocated by Sharp (1987) and Vatcher (1987) were again relocated for this report by using the LOC program with the Lg velocity increased to 3.62 km/s (Fig. 6). The epicentres moved on average 8 km to the northeast, away from the seismological stations, as was to be expected. Because most pre-1968 earthquakes will probably be relocated using Lg phases that were read in a routine fashion (re-reading of the phases being too time consuming except for special projects), we have considered it important to adopt the new Lg velocity.

The LOC program simultaneously fits an epicentre and origin time by minimizing the weighted residuals on the phases that have been read. To relocate the earthquakes, the arrival times were weighted depending on how precisely the onset of the phase could be determined. Phases whose onsets could be determined to within $\pm$0.25 sec were weighted 1 (A), within $\pm$1 sec were weighted 1/4 (B), and within $\pm$4 sec were weighted 1/16 (C). Phases whose onset could not be determined with much precision were given a zero weight (X). In addition, some phase readings – even those made precisely – occasionally gave very large residuals (> 4 sec) and these were given zero-weight (XA, XB, etc) to avoid distorting the solution. LOC also calculates the distance from the epicentre to each station, the azimuth to each station from the epicentre (clockwise from north), the residual for each measured phase, the standard error of each parameter of the epicentre, and the final root-mean-square error. The computed errors reflect only the consistency of the data set and not the actual uncertainty in the epicentre (i.e. precision rather than accuracy).

Re-determining magnitudes

Magnitudes were also recalculated for the earthquakes. Prior to the late 1960's, the Richter magnitude, M_L, originally developed by Richter in 1935 for California earthquakes (Richter, 1958) was used for local Canadian earthquakes. The equation presently used by the LOC program is

$$M_L = log_{10}\frac{(A \ K_{WA})}{K} - log_{10}A_o$$

$A = half \ \ maximum \ \ seismogram \ \ amplitude \ \ (peak - to - peak) \ \ in \ \ mm$

$K = seismograph \ \ magnification \ \ in \ \ 1000's$

$K_{WA} = Wood - Anderson \ \ magnification \ \ in \ \ 1000's \ \ at \ \ period \ \ of \ \ A$

$A_o = amplitude \ \ for \ \ a \ \ standard \ \ earthquake$

(see Table 22-1, p. 342, of Richter, 1958)

with the restrictions: $\Delta \leq 600$ km and T (period) < 2.5 sec. The Richter Scale had been developed using a California attenuation, which was subsequently found to be inappropriately high for North American earthquakes east of the Rockies. The Lg waves propagate much more efficiently in eastern North America than in California, thus the M_L magnitudes calculated from the largest amplitude on the seismogram were generally too high, especially at large distances.

A new magnitude scale was developed in the early 1970's by O. W. Nuttli (1973) and is in common use by the Geophysics Division. The Nuttli scale (m_N) is based on the maximum amplitude of the Lg waves and has been found to provide more reasonable magnitudes for eastern Canadian earthquakes. The initial restrictions proposed by Nuttli (0.7 sec $<$ T $<$ 1.3 sec and $\Delta > 4$ degrees (or 444 km)), have been relaxed for Geophysics Division computations to T $<$ 1.3 sec and $\Delta > 50$ km because the additional magnitudes so computed were found to be consistent with those computed according to the original definition.

$$m_N = -0.1 + 1.66 \ log_{10}\Delta + log_{10}\frac{A}{KT}$$

$\Delta = epicentral \ \ distance \ \ in \ \ km$

$A = half \ \ maximum \ \ seismogram \ \ amplitude \ \ (peak - to - peak) \ \ in \ \ mm$

$K = seismometer \ \ magnification \ \ in \ \ 1000's$

$T = seismogram \ \ period \ \ in \ \ seconds$

Both magnitudes (M_L or m_N) are calculated at each station by measuring the largest amplitude recorded and its period, and by knowing the station's magnification factor. The magnification factor can be read from calibration curves in the seismological bulletins (e.g. Hodgson, 1959). The overall m_N or M_L magnitude is then determined by averaging the individual station magnitudes that meet the distance and period restrictions noted above.

Revised magnitudes in this report result firstly from choosing the m_N scale over the M_L scale, and secondly (and less importantly) from adding amplitude and period data from additional Canadian seismograms not read by Smith, and adding Ebel's (1987) amplitude and period data from WES. Neither body-wave (m_b) nor surface-wave (M_s)magnitudes were calculated for any earthquakes in this study.

RESULTS: EPICENTRES

Using the LOC program, forty-six Lower St. Lawrence earthquakes from 1928 to 1968 were relocated. For events studied by Sharp (1987) and Vatcher (1987), the original seismograms were re-read wherever possible (some records had been lost or misplaced) and the arrival times previously read were verified. Appendix D has examples of portions of the seismograms from a few of the early relocated earthquakes. For events studied by Connors (1988), the original records were re-read only where there seemed to be inconsistencies, or where new phases were necesssary to confirm the location.

A summary of the revisions made to the relocated earthquakes can be found in Table 1. Details of the relocated solutions are in Appendix E, which also contains detailed comments on the phases and solutions. Figure 7 shows a map of the relocated earthquakes. The earthquakes are mapped at their revised locations and the tails point back to their old epicentre. The median distance moved is 35 km. A few of the events would have also changed symbol size as they moved, had symbols also been plotted at the old epicentre. This is a result of switching from the Richter magnitude scale (M_L) to the Nuttli scale (m_N), which generally caused a reduction in the magnitude. Figure 8 shows the new epicentres with diagonal boxes showing the precision of the computed epicentre (large boxes represent poorly determined epicentres).

In the following discussion, and in Table 1, earthquakes are denoted by their date, for example, #44b, which is the second earthquake in 1944.

The first earthquake, #30, was recorded only at SFA, was felt at "Rivière Bersimis (now Rivière Betsiamites) and points on the north shore of lower Saint Lawrence" (Smith's

comments), and assigned to the town of Betsiamites at the mouth of the river. The epicentre is consistent with the Lg–Sn interval on SFA, which indicates an epicentral distance of about 250 km. However, the earthquake could have occurred anywhere in the southwest part of the Lower St. Lawrence.

#38 is poorly located because of station distribution, and had been assigned by Smith to the nearest degree of latitude and longitude. Our relocation places it towards the south shore, but it could have occurred anywhere under the river.

#42 is the first LSL earthquake for which we or Smith used WES readings. The slightly improved epicentre has moved east across the river 28 km.

#44a is the largest earthquake (m_N 4.8) now known from the LSL, and was well recorded on the seismographs of the day. We have re-determined its epicentre to lie under the river off Rivière Pentecôte, about 44 km east of Smith's location.

#44b occurred $2\frac{1}{2}$ months after #44a and relocated by a similar amount and in the same direction.

#44c was located "in the mouth of the St Lawrence River" by Smith, but his coordinates place the epicentre 1° further south in Gaspé, which might have been a transcription error. Sharp (1987) relocated the earthquake to the St. Lawrence River, but seismograms obtained from Weston suggest that the earthquake occurred on the north shore, in the Manicouagan River valley.

#46 moves 72 km towards the river because weak Pn phases at SFA and OTT were not used.

#48 had been located to the nearest degree. It remains in the Manicouagan Valley, but is still poorly located.

#50 moved to Baie des Chaleurs, New Brunswick because of the addition of U.S. data. A newspaper in Chatham, N. B. records that this earthquake awakened some people in Newcastle and outlying areas (K. Burke, University of New Brunswick, pers. comm., 1987). Both the computed epicentre and the available felt report indicate that #50 is not a Lower St. Lawrence earthquake.

#51a moved 50 km from the north shore of the Lower St. Lawrence towards the river. The possibility that this was instead a New Brunswick earthquake in the Newcastle area, like #50, is considered unlikely because none of the local newspapers record an earthquake being felt at this time (K. Burke, University of New Brunswick, pers. comm., 1988).

Of the 1950's events not discussed individually below, #51b, #54a, #54b, #57, #58, and #59a move by smaller amounts (4 to 56 km), generally towards the river.

#53a is the first earthquake for which the short-period Benioff at Halifax is available to provide distance control in the northwest-southeast direction. It moves from the Gaspé Peninsula, where it was felt, into the St. Lawrence River.

#53b also moves from the Gaspé Peninsula north into the St. Lawrence River, similar to #53a, and is interesting because of the effort required to estimate the time correction on SFA (Appendix B).

#56a and #56b are a double event (or perhaps a triple event) that occurred within a minute. The second was slightly larger than the first. The seismograms are complicated and have multiple phases which cannot always be assigned unambiguously to the correct event. Both events are assigned to the epicentre for the first, which at least has two unambiguous Pn arrivals from orthogonal azimuths. Smith had also assigned both earthquakes to the same epicentre. The relocation places the pair of events on the Gaspé Peninsula.

#56c and #56d are a second double event that occurred within 23 minutes. Both epicentres are pegged at the location of the first and larger earthquake, and have moved to lie on the north shore (northwest of Forestville), chiefly because of the addition of some rather poor phases from HAL, which apparently had not been read.

#59b moved east 80 km from the Manicouagan valley to lie on the north shore, close to the river. The solution is poor because no P phases were read.

Of the 1960's events not discussed individually below, #64a, #64b, #66a and #66b (a double event), #66c, #66i, #67a, #67b, and #67c move by smaller amounts (5 to 22 km), generally towards the river.

#61, which has extensive felt reports in Appendix F, relocates to Port Cartier (20 km) and, because of the revised Lg velocity, lies 20 km to the north of the position computed by Sharp (1987).

#62 moved 600 km away from the Lower St. Lawrence region, from Sept-Îles to just east of Québec City. The change arises from confusion with the time of a possible felt earthquake at Sept-Îles (see Appendix E for details). On the SCH record we saw no evidence for a $M > 3$ earthquake at Sept-Îles at the time reported, and presume the felt report to be erroneous. The seismic energy reported from MNT belonged to an event we locate near Québec City. Pierre Gouin (pers. comm., 1988) has searched the Québec City newspapers for reports of a felt earthquake, but without success. It is possible that the event is a quarry blast.

#63 moves east 190 km, the result of choosing the alternative epicentre (it was recorded only at SIC and SCH). This small earthquake did not produce phases on any other seismogram, and must be considered poorly located.

#64c moves only slightly, but the location is now more certain as new phases have been added, which have eliminated the alternate epicentre (which was previously rejected by Observatory staff).

#65a and #65b (a double event, spaced 5 minutes apart) moved significantly to the east, probably because more phases were read. However, because none of the original readings was found, the basis for the original epicentre is not known.

#65c moves 56 km east-southeast from the northshore into the river.

The cluster of activity (#66d - #66h) at 49.5°N and 68.5°W (studied by Vatcher, 1987) are possibly induced earthquakes associated with the 1965 filling of the Manic-2 reservoir. All six events lie a similar distance from the closest station (SIC), and cluster within a 10 km radius of the centre of the reservoir. The scatter in the epicentres is about the same as the precision of the individual epicentres, so the size of the active zone is not known.

#68 had unusually large residuals on the closest station when fixed at a depth of 18 km, and because a shallow hypocentre fitted the data substantially better, the event was finally fixed at zero depth (at the surface). While shallow earthquakes (depths of 0-5 km) do occur, it seems possible that the event might have been a construction blast. In the absence of proof we leave it in the earthquake epicentre file. It should be noted that the data contain no depth information; the closest station SIC ($\Delta \approx 25$ km), has only a single phase reading (P) and the remaining stations are more than 400 km distant.

RESULTS: MAGNITUDES

Some of the earthquakes studied had had magnitudes recalculated by R. B. Horner in the late 1970's using the m_N scale (published by Basham et al., 1982, Appendix C, and then used to revise the Canadian Earthquake Epicentre File (CEEF)). Early events in the CEEF with m_N rather than M_L magnitudes represent those calculated by Horner. For Horner's events, our recalculated m_N is within 0.1 magnitude unit of Horner's value (see Table 1). We give in Table 1 only M_L values for those earthquakes having an M_L value in the CEEF. Our values are close to the catalogued values except where the epicentral location moved significantly. As noted above, the M_L scale is now known to be inappropriate for the earthquakes studied in this report. The prefered magnitude values for the revised earthquakes are, without exception, the m_N values.

Twenty-nine of the earthquakes in Table 1 have had m_N magnitudes calculated for the first time, and for each one the m_N magnitude is about 0.4 to 0.5 units less than the previous M_L, as expected. One of the most important changes is for event 44b, which no longer is larger than magnitude 5. The largest known earthquake from the seismic zone is now only m_N 4.8 (event 44a). The most dramatic change in magnitude is for event #62, which changes from M_L=4.6 to m_N=3.2 because the epicentre has been substantially revised.

While recalculating the magnitudes of the relocated earthquakes, it was noticed that two events in Basham et al. (1982) appeared to have increased in magnitude from the M_L to the m_N calculations, which is highly unusual. We confirmed that the m_N clculations were correct, and after some investigation discovered that the M_L's were in fact USCGS m_b's. The corrected events are as follows (only the second is a Lower St. Lawrence earthquake):

No.	Year	Mo	Day	Time	Lat	Lon	m_b	m_N
111.	1967	06	13	19:08	49.2	78.2	3.9	4.5
113.	1967	09	30	22:39	49.5	65.8	4.2	4.7

They should in fact have had M_L values of 4.9 and 5.2 respectively. However in both cases, m_N is the preferred magnitude.

DISCUSSION

As mentioned above, the results are summarized by Figure 9 and Table 1. The general trend for earthquakes to relocate into the river is apparent, as is also the size of the revisions for events #50 and #62. Of the 46 earthquakes, these two moved more than 300 km. Together with other relocation studies recently completed, this suggests that 5% to 10% of the earthquakes of this epoch are very poorly located.

Most of the relocated events have moved along a northwest-southeast axis, towards the river. This is not surprising since it is in this direction that the greatest uncertainty lies. Ottawa, Shawinigan Falls and Seven Falls lie to the southwest (Fig. 5) and locate the earthquake well in distance from these three stations; however because they are colinear

the azimuth is only well determined when a station like Halifax, Schefferville, or Weston is available to provide north-south control.

The relocations move one earthquake to New Brunswick (and one to Québec City, discussed above), leave four earthquakes (two a double event) on the Gaspé Peninsula, leave six earthquakes near the Manic-2 reservoir, and leave six earthquakes (two a double event) on the north shore (at least 10 km inland from the St. Lawrence River); these groupings and the seismicity beneath the river and within 10 km of the shores are discussed below.

New Brunswick Earthquake

Earthquake #50 has moved over 300 km from the north shore of the St. Lawrence to the northeastern part of New Brunswick as a result of adding WES readings. For earthquakes located by drawing arcs from OTT, SHF, and SFA, the Lower St. Lawrence and northeastern New Brunswick are the two possible intersection points; in the absence of felt reports Smith correctly considered the Lower St. Lawrence to be the most active area and so placed the earthquakes there. The Weston readings confirm that the earthquake was closer to WES than the Lower St. Lawrence Seismic Zone is to WES, and the earthquake is now known to have been felt locally in New Brunswick. This earthquake is consistent with the moderate level of seismicity in the northeastern part of New Brunswick.

Gaspé Peninsula Earthquakes

Of the four Gaspé earthquakes two are a double event (#56a and #56b) that has moved onto the peninsula, and the other two earthquakes (#59a and #67b), considering the error associated with their old and new locations, were apparently well-located initially. These are possibly the only Gaspé earthquakes known prior to 1969 other than the "earthquake felt at Gaspé," November 22, 1884 (Smith, 1962) which may not have been a nearby earthquake. Although no time was given by Smith, his prime reference (Dawson, 1896) gives the following: "Nov 22. Shock felt between St. Flavie and Gaspé last night, lasting 45 to 50 seconds". This makes it clear that the felt report was not associated with the New Hampshire earthquake at 12.30 am on November 23rd, and makes it likely that the felt report is associated with the second of two Lower St. Lawrence earthquakes that occurred on the night of the 21/22 (Smith, 1962).

Manic-2 Earthquakes

The six earthquakes (#66d to i) near the Manic-2 reservoir (near 49.5°N 68.5°W) do not move significantly. Leblanc and Anglin (1978) make the following comment: "Clustered downstream from the Manic-3 dam in the region of the Manic-2 reservoir is a series of six events that occurred from mid-July 1966 to mid-August 1966, with magnitudes $2.7 < M_L < 3.7$. The reservoir of Manic-2 is relatively smaller (than Manic-3): 3.3×10^9 m^3; the height

of the dam just under 100 m. The rapid filling was done in 4 months and completed in July 1965. The possibility exists that these 1966 events were somehow related to the filling of the Manic-2 reservoir, but failed to be recognized as such." The magnitudes are now $2.5 < m_N < 3.3$. The six epicentres have a similar epicentral distance from SIC, and scatter about northwest-southeast trend. A 'master event' or joint epicentre location of these earthquakes might reveal further details of the spatial extent of activity, which at present seems to extend under the northern half of the reservoir.

Other North Shore Earthquakes

Of the six other earthquakes clearly on the north shore, two (#56c,d; a double or possibly triple event in 1956) have moved away from the St. Lawrence River to lie northwest of Forestville, though the epicentre is still rather uncertain and perhaps should be re-examined when the earthquakes that lie just to the northeast of the Saguenay are systematically relocated. One other earthquake (#64a) is small and similar in size to others occurring on the north shore today, and another (#68) might possibly be a construction blast.

The remaining two earthquakes are interesting. #48 has an acceptable epicentre (based largely on WES readings because of the poor quality of the KLC phase) similar to the one adopted by Smith, while #44c has (based again on the WES reading) moved from the south shore, not to the river as postulated by Sharp (1987), but to very close to #48. Both locate in the Manicouagan Valley, upstream from the Manic-3 induced seismicity, and may suggest that a weak trend of seismicity follows the Manicouagan Valley.

Seismicity under the St. Lawrence River

The relocation of the earthquake epicentres away from the shores and under the St. Lawrence River leaves both the north and south shore with low level of seismicity, in strong contrast to the relatively high level of seismic activity found under the river. The relocated epicentres have a distribution generally similar to the more recent earthquakes (compare Fig. 9 with Figs 2 and 3); however three interesting observations can be made.

Firstly the bulge of the north shore inland of Pointe-des-Monts is substantially aseismic, and the larger 1928 - 1968 earthquakes tend to lie about 15 km off the coast, and form a trend parallel to the coast. Stagg (1986) has provided some evidence that the Lower St. Lawrence earthquakes may be occurring by reactivation of the Paleozoic rifts of the St. Lawrence Valley (see also Adams and Basham, 1989); if so, these same faults may be controlling the shape of the coastline and perhaps do not cut across the bulge.

Secondly, the activity near 49.5°N 66°W (offshore of Mont-Louis), which includes three magnitude 4 earthquakes, is poorly reflected by the modern seismicity. These earthquakes all occurred in the 50's and 60's, and apparently since then there has been a much

lower level of activity. By contrast, the area near 49.4°N 66.7°W, about 50 km to the west, had no recorded earthquakes from the 1928-1968 period but has been moderately active from 1968 onwards. Either the early activity off Mont-Louis is misplaced (unlikely since the station coverage was quite good), or the activity in this part of the seismic zone has fluctuated with time.

Thirdly, the recent, well-located 1982-87 seismicity on Figure 2 suggests the presence of a northeast-trending aseismic corridor about 50 km long extending from the south shore near 67.5°W to about 49.7°N 66.5°W. The significance of this corridor is not known, but it may resemble one documented by Anglin (1984) at Charlevoix. An intriguing observation (that may be an artifact) is that the larger, relocated epicentres on Figure 9 show a similar northeast trend. Although they have the same trend, the inaccuracy of the epicentres prevents deciding whether the apparent northwest displacement of the epicentral trend from the aseismic corridor is significant.

The revised epicentres in Figure 9, together with the more recent epicentres on Figures 2 and 3 suggest that the spatial extent of the Lower St. Lawrence seismic zone shouild be revised to more closely reflect the concentration of earthquakes under the river. The polygon in Figure 9 offers a suggested revision.

Felt reports for the 1928 - 1968 earthquakes

Felt reports have been published for four of the relocated earthquakes prior to 1959 (Smith, 1966). Earthquakes #30 was felt at Betsiamites and unspecified points on the north shore. Smith reports the January 1953 earthquake (#53a) was "felt in the Gaspé Peninsula". For the September 1953 earthquake Smith comments: "Replies to questionnaires show that the shock was felt along the north coast of the Gaspé Peninsula from Ste-Marthe-de-Gaspé eastward to Pointe-Jaune. Its effects were strongest near the middle of this extent at Rivière-la-Madeleine and Grande-Vallée, where the intensity was IV-V. It was not felt farther south on the peninsula except at Cortéréal, from which intensity II was reported". We think that partly on the basis of the felt reports, Smith placed the epicentre on the south shore (but by giving the associated error as $\pm 0.5°$ he was aware that it might lie under the river); we have relocated the epicentre to lie under the river (#53b). The September 1967 earthquake (#67c) was felt in Mont-Louis and Rivière-au-Renard on the south shore, and Sept-Îles and Clarke City on the north shore (Stevens et al., 1973).

Quite extensive felt reports are available for the 1961 earthquake, which was analysed by Milne and Smith (1962). We provide full details of the felt reports, a new assessment of the felt intensities in each place (which has been reviewed by A. E. Stevens), and a

new intensity map in Appendix F. The chief differences from the Modified Mercalli (MM) intensities assigned by Milne and Smith are: MM V for Port Cartier, MM IV for Tika, MM III for Rivière-Pentecôte, and the plotting of the "not felt" localities. As noted by Milne and Smith, there is insufficient information to construct isoseismals; however the intensity at Port Cartier is now seen to be consistent with the revised epicentre.

The 1961 earthquake shows the type of information that might be available for the older earthquakes. The relocations made here should be tested by examining any north shore and Gaspé newspapers for reports of the earthquakes. Earthquakes under the river of magnitude ≥ 4 could have been felt on both shores, and so the felt reports might be used to confirm some of these relocations.

CONCLUSIONS

Twenty-seven of the 46 earthquakes studied in the period 1928-1968 have been found to lie under or very close (within 10 km) to the St. Lawrence River. As expected, the epicentres tended to move along a northwest-southeast axis. For some of the more modern earthquakes, the size of the revisions was not large and was comparable to the estimated accuracy of the epicentres, confirming that earthquakes with good data were well-located even before the advent of computer-calculated epicentres. However, adding additional phases (mainly from United States seismographs) to those early events that had been located using minimal data, resulted in two epicentres being revised by over 300 km. Our experience with these and other events suggests that perhaps 5% to 10% of all early-instrumental (pre-1968) earthquakes are badly located (>1°). Adopting an Lg velocity of 3.62 km/s – the chief revision to the velocity model for eastern Canada – removed a 10-km southeasterly bias from many of the early epicentres; however this bias is small relative to the final uncertainty of the adopted epicentres.

The relocation of the 1928 - 1968 earthquake epicentres in the Lower St. Lawrence demonstrated that over half of the pre-1969 epicentres plotted on the north shore were mislocations. The level of seismicity on the north shore was shown to be quite low. Of the confirmed earthquakes, most were associated with the filling of the Manic-2 and Manic-3 reservoirs, so the level of **natural** seismicity is still lower. The low level, which also prevails on the south shore, contrasts greatly with the higher level under the river itself. Activity under the river occured from 65°W to approximately 69°W without any strong

concentrations, although some possible linear trends were identified. These distinctions will be of considerable significance for future seismic hazard zoning of the region, as the present large seismic zone "LSL" defined and used by Basham et al. (1982) was drawn to encompass the mislocated seismicity on the north shore. The zone should now be redefined to correspond more closely to the seismic activity under the river.

ACKNOWLEDGEMENTS

This Open File has been derived from student work reports cited in the text. The project was conceived, directed, and quality-checked by J. Adams. We would like to thank Dr. Anne Stevens for her helpful comments on the relocations, F. M. Anglin for assistance with the mapping programs, R. J. Halliday for obtaining the historical seismograms, and other staff members of the Geophysics Division for assistance in many varied ways. The current text has benefited from careful editing by P. W. Basham and A. E. Stevens.

REFERENCES

Adams, J., and Basham, P.W., 1989. The seismicity and seismotectonics of eastern Canada: Geoscience Canada v. 16, p. 3-16.

Adams, J. and Staveley, M., 1985. Historical seismicity of Newfoundland, Earth Physics Branch Open File 85-22, 73 pp.

Adams, J., Sharp, J., and Stagg, M., 1988. New focal mechanisms for southeastern Canadian earthquakes: Geological Survey of Canada Open File 1892, 109 pp.

Anglin, F.M., 1984, Seismicity and faulting in the Charlevoix zone of the St. Lawrence Valley: Bulletin of the Seismological Society of America, v. 74, p. 595-603.

Basham, P.W., Weichert, D.H., Anglin, F.M., and Berry, M.J., 1982. 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, 202 p.

Connors, K., 1988. The seismicity of the St. Lawrence rift system and its seismic hazard. Unpublished Co-op Student Work Report for the Geophysics Division, 84 pp.

Connors, K. and Adams, J., 1988. Velocity of the Lg phase from Lower St. Lawrence earthquakes, Geological Survey of Canada, Seismology Internal Report 88-7, 18 pp.

Dawson, J. W., 1896. Our record of Canadian earthquakes. Canadian Record of Science, v. 6, p. 8-16.

Ebel, J. E., 1987. Northeastern earthquake magnitudes from 1938 to 1975, Final Report, U. S. Geological Survey Contract 14-08-0001-22049, March 1987, 44 pp.

Hodgson, J.H., 1959. Seismological Bulletin, January-March 1959, Seismological Series of the Dominion Observatory, Department of Mines and Technical Surveys, Ottawa, 88 pp.

Hodgson, J.H., 1961. Seismological Bulletin, January-March 1961, Seismological Series of the Dominion Observatory, Department of Mines and Technical Surveys, Ottawa, 73 pp.

Leblanc, G. and Anglin, F., 1978. Induced seismicity at the Manic-3 Reservoir, Québec, Bulletin of the Seismological Society of America, Vol.68, No.5, pp. 1469-1485.

Milne, W.G., and Smith, W.E.T., 1962, Canadian Earthquakes – 1961, Seismological Series of the Dominion Observatory 1961-4, 24 pp.

Nuttli, O.W., 1973. Seismic wave attenuation and magnitude relations for eastern North America, J. Geophysical Research, vol. 78, p. 876-885.

Richter, C., 1958. Elementary Seismology, W.H. Freeman and Company, Inc., 768 pp.

Sharp, J., 1987. Relocation of early-instrumental earthquakes in the Lower St. Lawrence. Unpublished Co-op Student Work Report prepared for the Geophysics Division, 73 pp.

Smith, W.E.T., 1962. Earthquakes of eastern Canada and adjacent areas 1534-1927: Publications of the Dominion Observatory, Department of Mines and Technical Surveys, v. 26, p. 271-301.

Smith, W.E.T., 1966. Earthquakes of eastern Canada and adjacent areas, 1928-1959: Publications of the Dominion Observatory, Department of Mines and Technical Surveys, Ottawa, v. 32, p. 87-121.

Stagg, M., 1986. Seismicity of the Lower St. Lawrence, Unpublished Co-op Student Work Report prepared for the Geophysics Division, 36 pp.

Stevens, A. E., 1980a. History of some Canadian and adjacent American seismograph stations, Bulletin of the Seismological Society of America, Vol.70, No.4, pp. 1381-1393.

Stevens, A. E., 1980b. Reexamination of some larger La Malbaie, Quebec, earthquakes (1924-1978), Bulletin of the Seismological Society of America, Vol.70, No.2, pp. 1381-1393.

Stevens, A. E., Milne, W. G., Wetmiller, R. J., and Leblanc, G., 1973. Canadian Earthquakes – 1967. Seismological Series of the Earth Physics Branch No. 65, 65 pp.

Vatcher, H., 1987. Aspects of reservoir induced seismicity. Unpublished Co-op Student Work Report for the Geophysics Division, 61 pp.

Wetmiller, R.J. and M.G. Cajka, 1989, Tectonic implications of the seismic activity recorded by the northern Ontario seismograph network: Canadian Journal of Earth Sciences (in press).

Wetmiller, R.J., Horner, R.B., Stevens, A.E., and Rogers, G.C., Canadian Earthquakes – 1980. Seismological Series, Earth Physics Branch, Ottawa, No. 87, pp. 60.

Woodgold, C.R.D., 1989, Attenuation and velocity of seismic phases at regional distances in the Canadian Shield: (submitted to Bulletin of the Seismological Society of America).

Table 1
RELOCATION OF LOWER ST. LAWRENCE EARTHQUAKES

Note: The first line of each set contains the original data from CEEF files.
The second line contains the revisions obtained in this study.

No.*	DATE YY/MM/DD	S†	TIME HH:MM:SS	LAT. (°N)	ERR.	LONG. (°W)	ERR.	MAGNITUDE m_b	m_N	M_L	M_S	PM§
30	1930 10 08	**c**	01 08 41	48.93		68.70				3.9		M_L
			410	48.93		68.70			4.1			m_N
38	1938 05 17	**c**	18 32	49.0		68.0				4.6		M_L
			32 037	48.75	0.81	67.69	0.77		4.1			m_N
42	1942 09 11	**c**	11 05 13	49.22		67.40			3.7			m_N
			117	49.17	0.23	67.02	0.36		3.7			m_N
44a	1944 04 09	**s**	12 44 37	49.92		67.43			4.9			m_N
			349	49.77	0.08	66.86	0.08		4.8			m_N
44b	1944 06 23	**s**	06 37 53	49.42		67.75				5.1		M_L
			533	49.22	0.11	67.30	0.12		4.7			m_N
44c	1944 10 14	**s**	13 26 17	48.5		67.0				4.2		M_L
			154	50.25	0.07	68.51	0.06		3.7			m_N
46	1946 01 17	**s**	08 04 52	49.4		68.7				4.3		M_L
			05 023	48.81	0.17	68.27	0.16		3.8			m_N
48	1948 01 16	**c**	06 02 56	50.0		69.0			3.7	4.3		m_N
			499	50.22	0.18	68.65	0.26		3.6			m_N
50	1950 06 29	**s**	09 13 33	49.9		68.1				4.3		m_N
			115	47.88	0.08	64.89	0.12		4.3			m_N
51a	1951 06 28	**c**	01 03 57	50.0		67.5			4.2	4.8		m_N
			566	49.73	0.24	66.72	0.29		4.2			m_N
51b	1951 09 19	**c**	08 19 38	49.30		66.25			4.3	5.1		m_N
			351	49.27	0.14	66.00	0.17		3.9			m_N
53a	1953 01 24	**s**	09 58 37	49.07		66.00			4.6			m_N
			304	49.53	0.05	65.80	0.05		4.7			m_N
53b	1953 09 14	**s**	22 52 57	49.1		65.2			4.4			m_N
			518	49.60	0.06	65.14	0.07		4.3			m_N
54a	1954 01 10	**c**	21 04 297	49.17		68.23			3.1	3.9		m_N
			223	48.99	0.22	67.43	0.20		3.1			m_N
54b	1954 09 08	**c**	01 29 53	49.03		68.37			3.6			m_N
			566	48.86	0.11	68.33	0.07		3.6			m_N
56a	1956 08 03	**c**	12 51 385	49.42		66.17			3.5			m_N
			448	48.88	0.15	66.13	0.09		3.4			m_N

* Number-letter codes used in the report to refer to earthquakes.

† Earthquake originally studied by – **s:** Sharp, 1987; **v:** Vatcher, 1987; **c:** Connors, 1988.

§ Preferred magnitude scale.

Table 1 (continued)

No.*	DATE YY/MM/DD	S†	TIME HH:MM:SS	LAT. (°N)	ERR.	LONG. (°W)	ERR.	MAGNITUDE m_b	m_N	M_L	M_S	PM§
56b	1956 08 03	**c**	12 52 088	49.42		66.17			3.6			m_N
			156	48.88	0.14	66.13	0.10		3.5			m_N
56c	1956 10 27	**c**	14 40 055	48.25		69.00				3.4		M_L
			052	48.81	0.09	69.71	0.05		3.4			m_N
56d	1956 10 27	**c**	15 03 53	48.25		69.00				3.4		M_L
			519	48.81	0.37	69.71	0.31		3.0			m_N
57	1957 10 16	**c**	19 13 265	50.50		64.87			4.1			m_N
			313	50.38	0.07	65.38	0.07		4.0			m_N
58	1958 10 21	**c**	09 32 514	49.60		68.00				4.1		M_L
			556	49.09	0.18	67.98	0.18		3.5			m_N
59a	1959 08 01	**s**	13 52 49	48.42		68.32				4.1		M_L
			510	48.46	0.05	68.32	0.03		3.5			m_N
59b	1959 09 25	**c**	01 36 302	50.18		68.20				3.9		M_L
			254	49.89	0.16	67.13	0.18		3.3			m_N
61	1961 07 05	**s**	22 43 44	50.25		66.68			4.3			m_N
			458	50.08	0.04	66.78	0.03		4.2			m_N
62	1962 12 15	**c**	00 58 32	50.20		66.38				4.6		M_L
			13 00 292	46.82	0.16	70.70	0.23		3.2			m_N
63	1963 10 19	**c**	06 29 344	50.0		67.8				2.9		M_L
			316	49.95	0.06	65.14	0.09		2.8			m_N
64a	1964 04 07	**c**	09 13 022	49.42		67.91				2.0		M_L
			003	49.45	0.04	67.96	0.06		2.2			m_N
64b	1964 07 01	**s**	21 41 30	49.43		67.42				3.8		M_L
			307	49.36	0.03	67.14	0.10		3.6			m_N
64c	1964 08 12	**c**	09 35 270	50.47		64.87				3.7		M_L
			306	50.41	0.04	65.01	0.04		3.1			m_N
65a	1965 03 18	**c**	12 04 29	49.77		67.53				2.8		M_L
			262	49.57	0.08	66.01	0.32		2.6			m_N
65b	1965 03 18	**c**	12 09 05	49.77		67.53				3.1		M_L
			013	49.57	0.04	66.01	0.10		3.0			m_N
66c	1966 07 12	**c**	01 06 01	49.50		66.00				3.3		M_L
			380	49.59	0.02	66.21	0.10		3.1			m_N
66d	1966 07 17	**v**	07 32 19	49.58		68.42				3.6		M_L
			195	49.57	0.03	68.46	0.04		3.3			m_N

* Number-letter codes used in the report to refer to earthquakes.

† Earthquake originally studied by – **s:** Sharp, 1987; **v:** Vatcher, 1987; **c:** Connors, 1988.

§ Preferred magnitude scale.

Table 1 (continued)

No.*	DATE YY/MM/DD	S†	TIME HH:MM:SS	LAT. (°N)	ERR.	LONG. (°W)	ERR.	MAGNITUDE m_b	m_N	M_L	M_S	PM§
66e	1966 07 21	**v**	19 29 25	49.50		68.33				2.4		M_L
			265	49.63	0.11	68.40	0.14		2.5			m_N
66f	1966 07 24	**v**	22 19 46	49.63		68.55				3.7		M_L
			482	49.60	0.02	68.38	0.05		3.4			m_N
66g	1966 07 27	**v**	11 12 43	49.42		68.42				3.4		M_L
			438	49.69	0.04	68.40	0.05		3.0			m_N
66h	1966 08 16	**v**	01 02 38	49.50		68.50				3.2		M_L
			385	49.50	0.05	68.32	0.10		2.9			m_N
66i	1966 08 20	**v**	13 13 33	49.58		68.33				3.5		M_L
			348	49.54	0.05	68.25	0.07		3.2			m_N
66j	1966 12 12	**c**	21 04 120	49.00		68.17				3.4		M_L
			123	49.09	0.02	68.25	0.07		3.3			m_N
67a	1967 02 27	**c**	04 12 556	49.17		66.00				2.3		M_L
			566	49.28	0.07	66.07	0.20		2.6			m_N
67b	1967 08 05	**s**	08 08 32	48.57		64.97				4.0		M_L
			312	48.65	0.02	64.93	0.07		3.4			m_N
67c	1967 09 30	**s**	22 39 51	49.48		65.78		4.2	4.7	5.3		m_N
			505	49.30	0.03	65.87	0.05		4.6			m_N
68	1968 09 29	**s**	10 04 48	50.14		67.22			3.6			m_N
			465	50.21	0.02	67.08	0.05		3.6			m_N

* Number-letter codes used in the report to refer to earthquakes.

† Earthquake originally stiudied by – **s:** Sharp, 1987; **v:** Vatcher, 1987; **c:** Connors, 1988.

§ Preferred magnitude scale.

FIGURE CAPTIONS

Figure 1. Map showing localities in the lower St. Lawrence mentioned in the text, together with the Lower St. Lawrence (LSL) seismic zone of Basham et al. (1982).

Figure 2. Seismicity of the Lower St. Lawrence, 1982 - 1987. The map shows earthquakes since the opening of the digital seismograph at GSQ and the consequent improved ability to detect and locate the many earthquakes smaller than M3. Most of the small earthquakes, and all the larger ones, in this six-year period lie under the St. Lawrence River.

Figure 3. Seismicity of the Lower St. Lawrence, 1969 - 1981. The map shows earthquakes from the beginning of computer-calculated epicentres to the opening of the seismograph at GSQ. Although the number of earthquakes located each year is fewer than in Figure 2, most are located under the St. Lawrence River. The most important exception is the M4 earthquake near 49.8°N 68.6°W, which was induced by filling of the Manic-3 Reservoir in 1975.

Figure 4. Seismicity of the Lower St. Lawrence, 1928 - 1968, as reported by Smith (1966) and the Canadian Earthquake Epicentre File, and **before** the revisions proposed in the present report. In contrast to Figures 2 and 3, most of the epicentres lie on the north and south shores and not under the river.

Figure 5. Early seismograph stations in southeastern Canada for the period 1928 to 1968. Not all of the stations operated high-gain short-period instruments for the entire period and not all operated simultaneously (see text and Stevens (1980a) for details).

Figure 6. Map of twenty Lower St. Lawrence earthquakes, identified in Table 1, previously located by Sharp (1987) and Vatcher (1987) using the standard velocity model, showing the result of then increasing the Lg velocity from 3.57 km/s to 3.62 km/s ("tails" point away from the '3.62' epicentre)(from Connors and Adams, 1988).

Figure 7. Revised seismicity of the Lower St. Lawrence, 1928 - 1968. Dots mark the new epicentres computed in this report, while the "tails" point back to the original epicentre. Year-letter combinations denote the individual events for easy comparison with Table 1, Appendix E, and the text.

Figure 8. As Figure 7, but diamonds replacing "tails" show the computed precision of the epicentres. For some epicentres the diamonds are smaller than the earthquake symbol.

Figure 9. Revised seismicity of the Lower St. Lawrence, 1928 - 1968 (same as Figures 7 and 8, but without the relocation vectors or diamonds). Compare with Fig. 3. The polygon indicates the suggested boundary for the revised Lower St. Lawrence Seismic Zone.

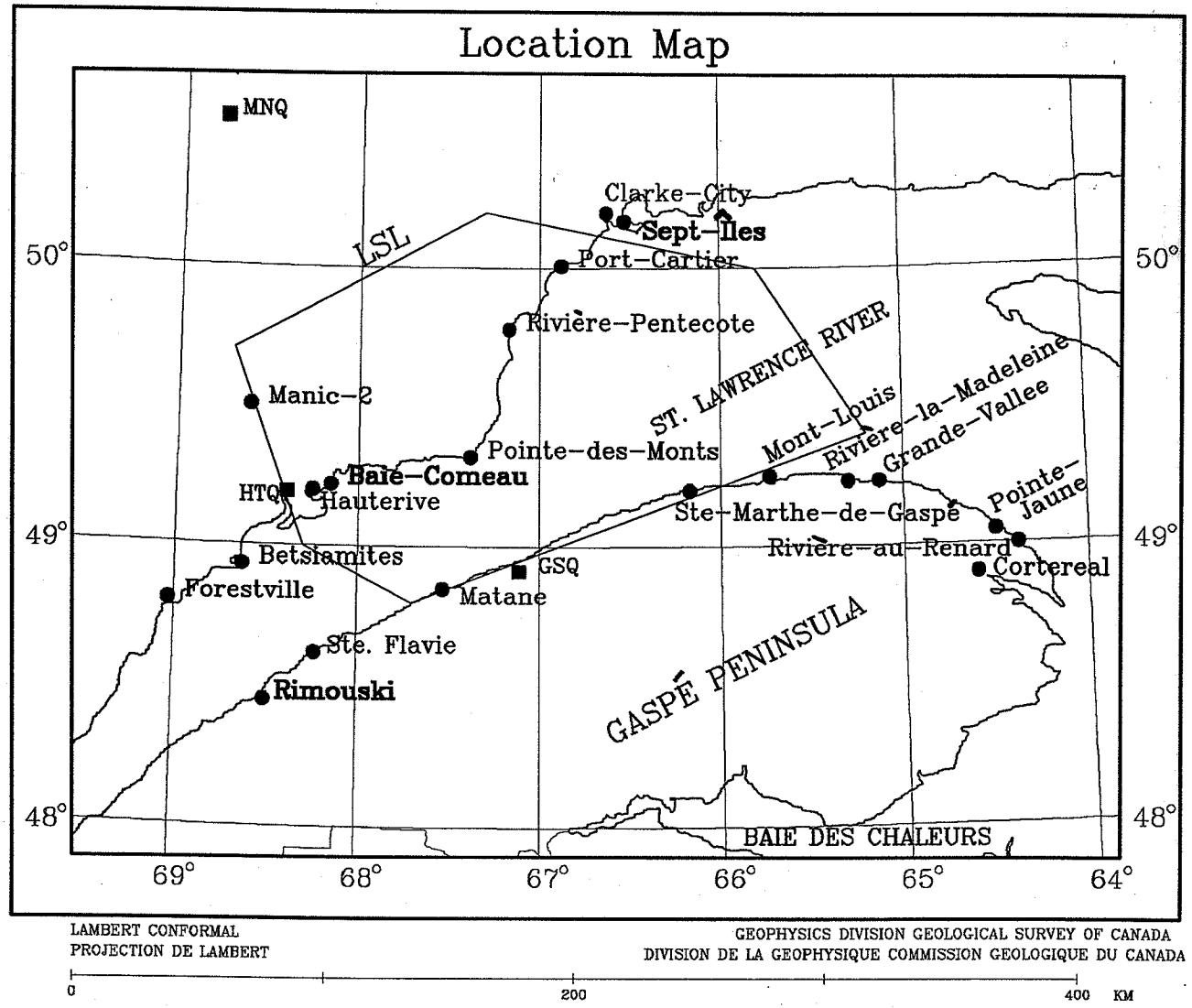


Figure 1. Map showing localities in the lower St. Lawrence mentioned in the text, together with the Lower St. Lawrence (LSL) seismic zone of Basham et al. (1982).

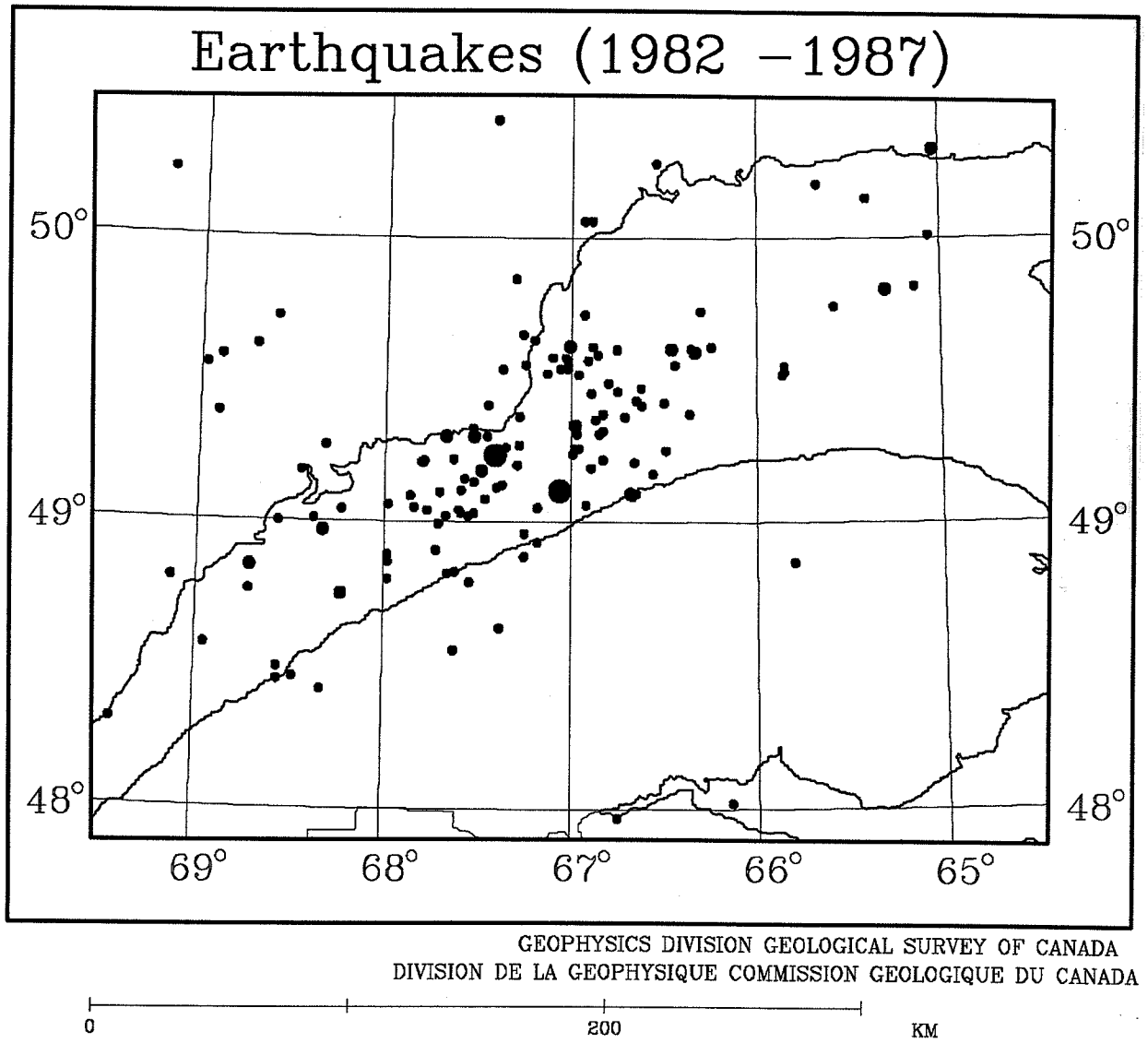


Figure 2. Seismicity of the Lower St. Lawrence, 1982 - 1987. The map shows earthquakes since the opening of the digital seismograph at GSQ and the consequent improved ability to detect and locate the many earthquakes smaller than M3. Most of the small earthquakes, and all the larger ones, in this six-year period lie under the St. Lawrence River.

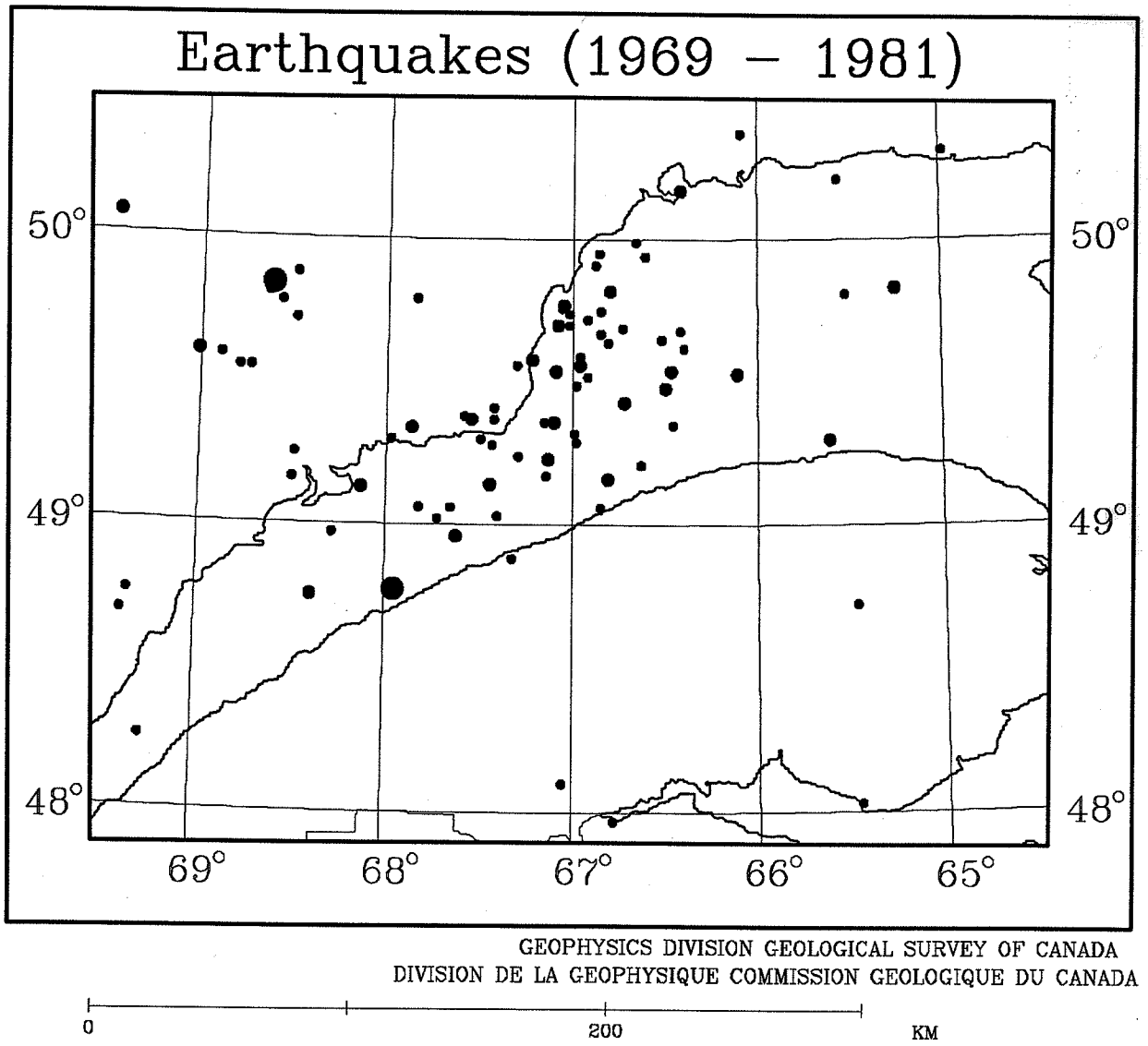


Figure 3. Seismicity of the Lower St. Lawrence, 1969 - 1981. The map shows earthquakes from the beginning of computer-calculated epicentres to the opening of the seismograph at GSQ. Although the number of earthquakes located each year is fewer than in Figure 2, most are located under the St. Lawrence River. The most important exception is the M4 earthquake near 49.8°N 68.6°W, which was induced by filling of the Manic-3 Reservoir in 1975.

DEFINITIONS

M<3
M≧3
M≧4

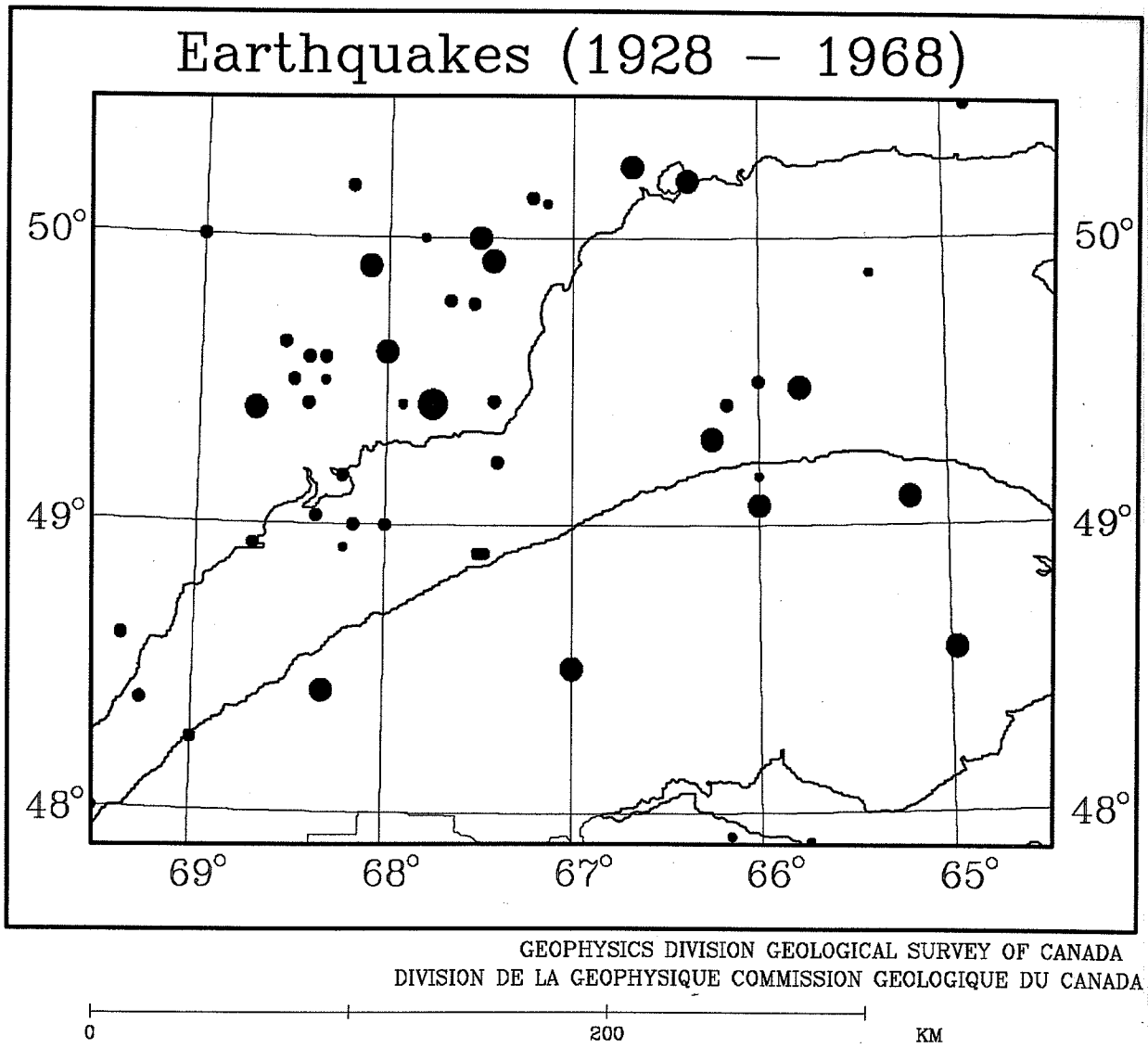


Figure 4. Seismicity of the Lower St. Lawrence, 1928 - 1968, as reported by Smith (1966) and the Canadian Earthquake Epicentre File, and **before** the revisions proposed in the present report. In contrast to Figures 2 and 3, most of the epicentres lie on the north and south shores and not under the river.

DEFINITIONS

M<3
M≧3
M≧4
M≧5

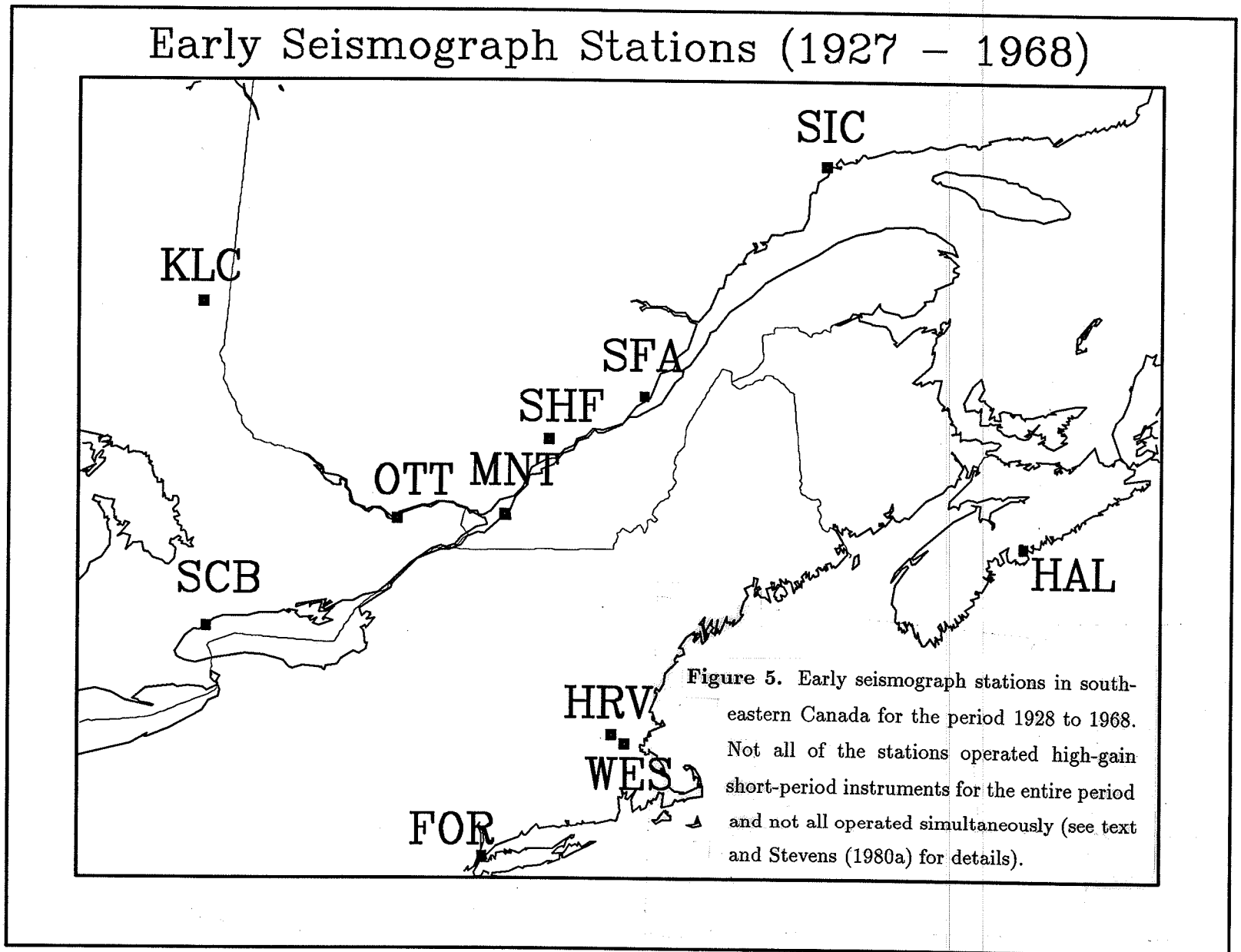


Figure 5. Early seismograph stations in south-eastern Canada for the period 1928 to 1968. Not all of the stations operated high-gain short-period instruments for the entire period and not all operated simultaneously (see text and Stevens (1980a) for details).

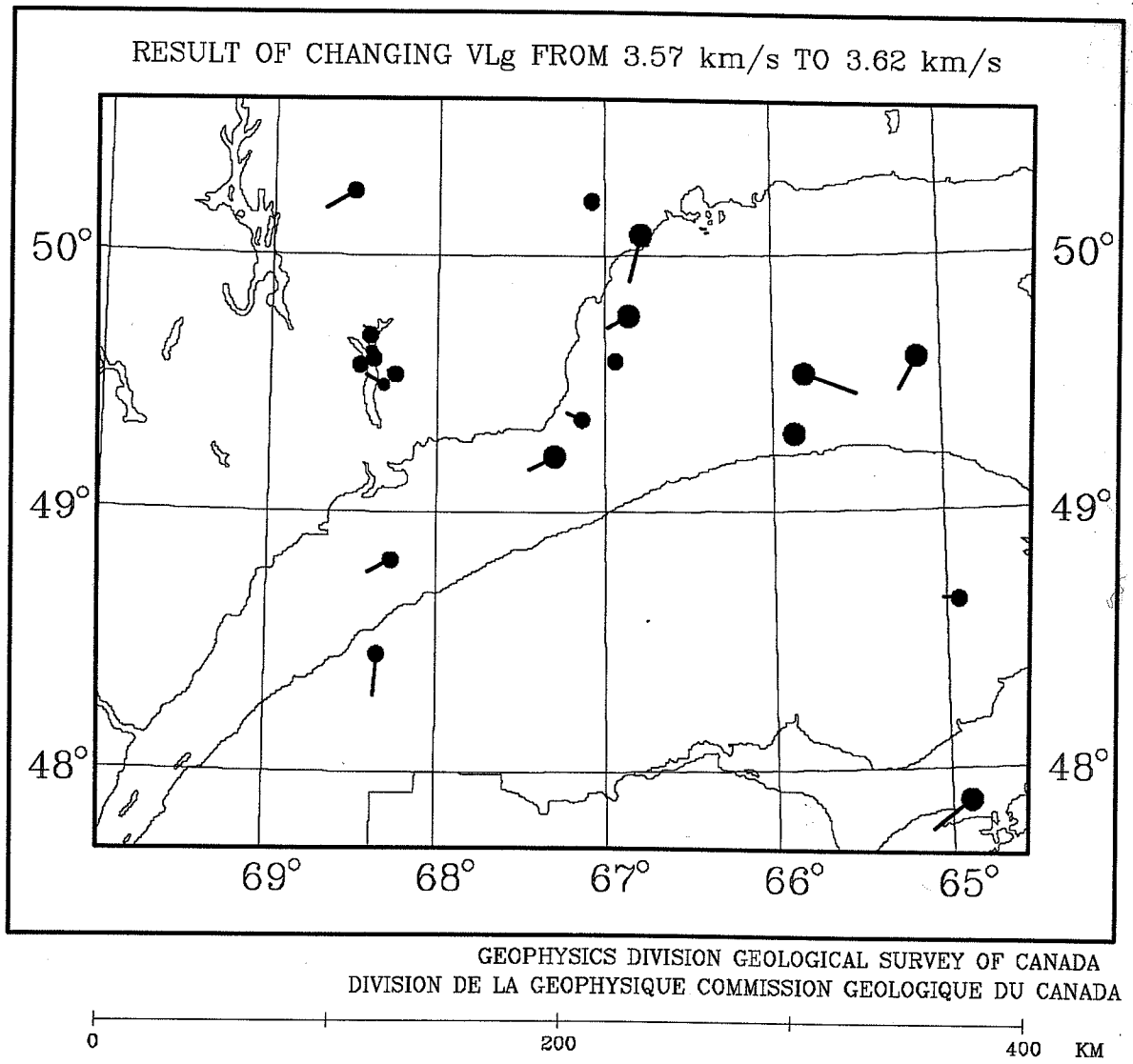
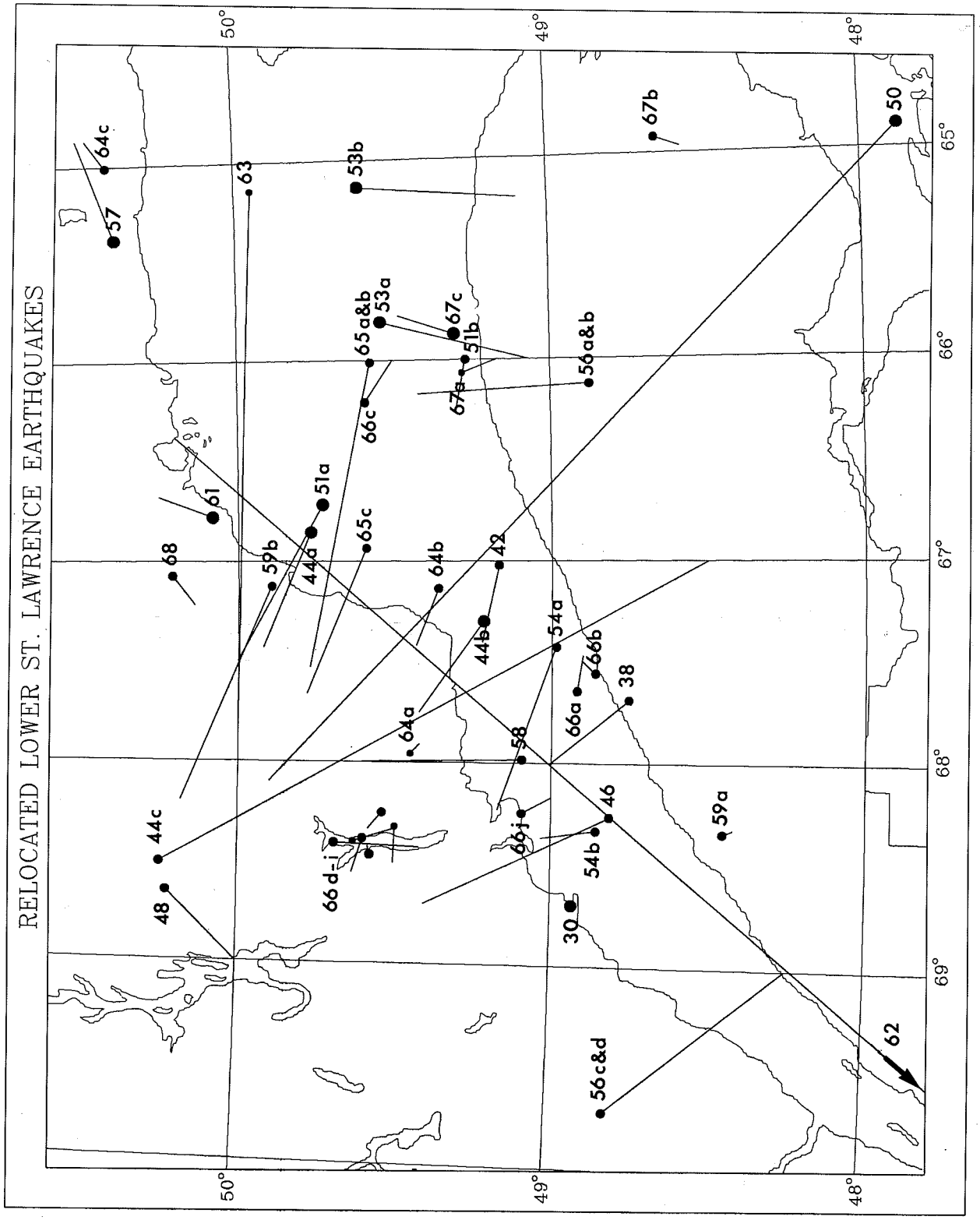


Figure 6. Map of twenty Lower St. Lawrence earthquakes, identified in Table 1, previously located by Sharp (1987) and Vatcher (1987) using the standard velocity model, showing the result of then increasing the Lg velocity from 3.57 km/s to 3.62 km/s ("tails" point away from the '3.62' epicentre)(from Connors and Adams, 1988).

DEFINITIONS

M<3
M≧3
M≧4

Figure 7. Revised seismicity of the Lower St. Lawrence, 1928 - 1968. Dots mark the new epicentres computed in this report, while the "tails" point back to the original epicentre. Year-letter combinations denote the individual events for easy comparison with Table 1, Appendix E, and the text.



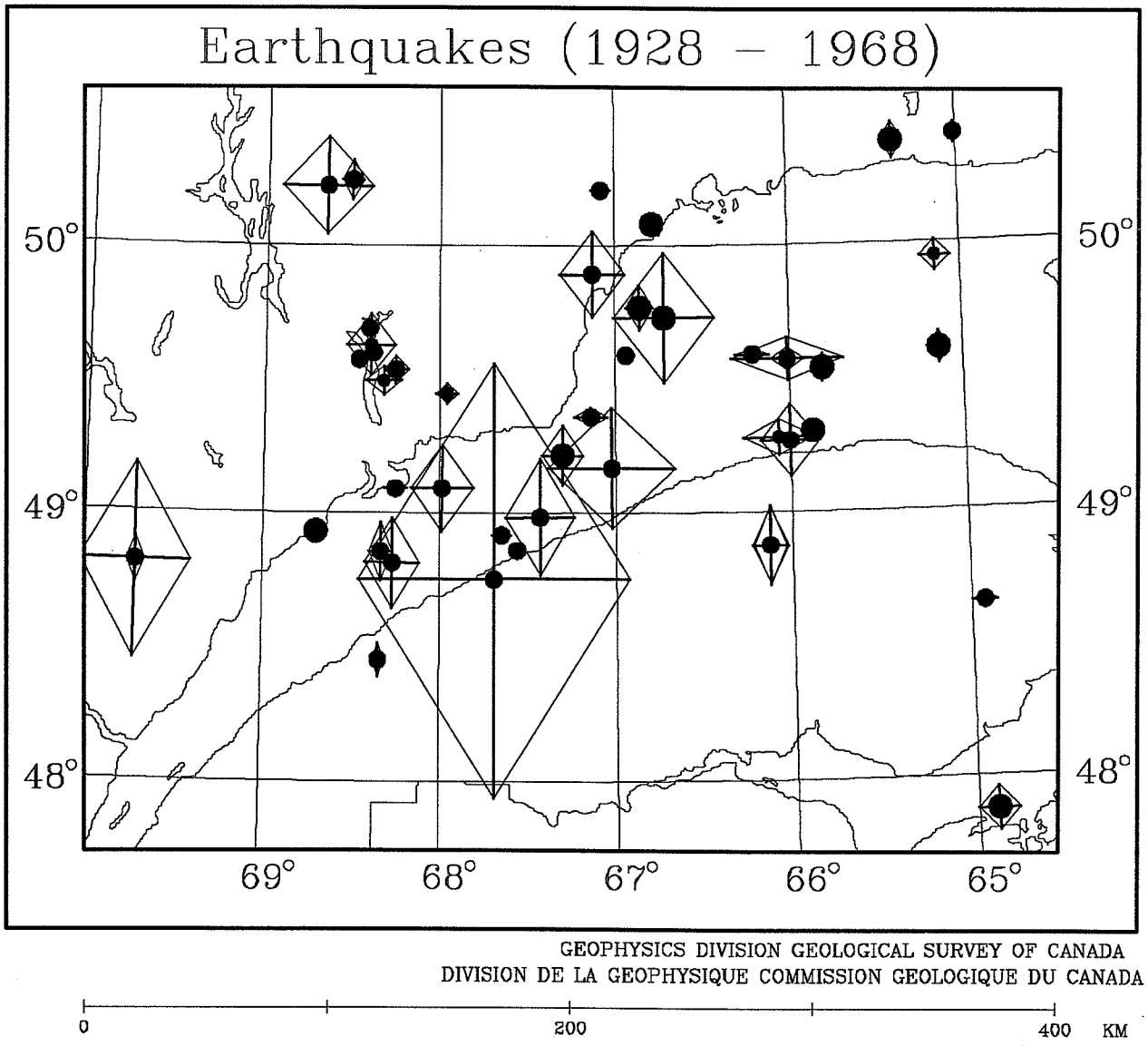


Figure 8. As Figure 7, but diamonds replacing "tails" show the computed precision of the epicentres. For some epicentres the diamonds are smaller than the earthquake symbol.

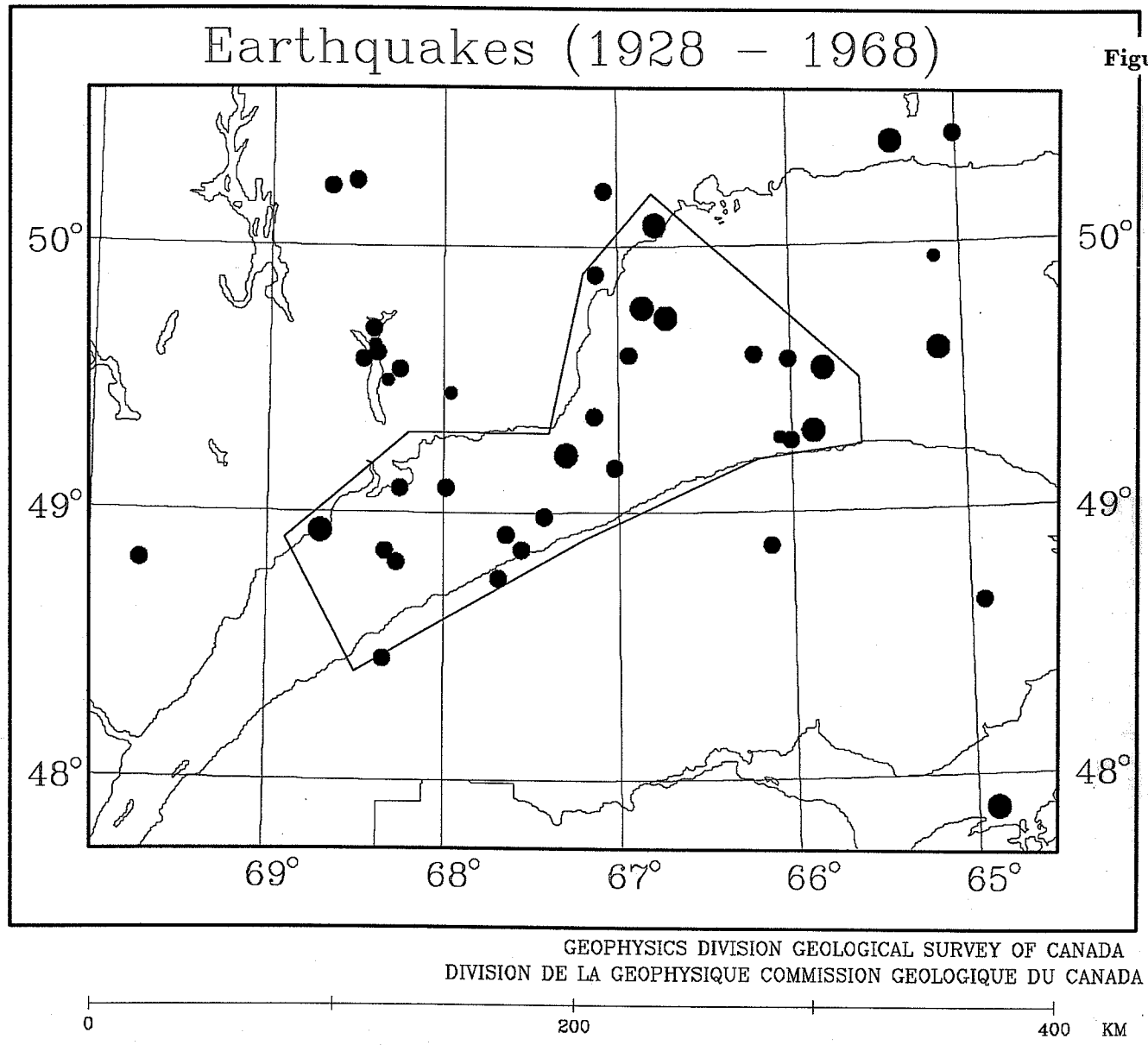


Figure 9. Revised seismicity of the Lower St. Lawrence, 1928 - 1968 (same as Figures 7 and 8, but without the relocation vectors or diamonds). Compare with Fig. 3. The polygon indicates the suggested boundary for the revised Lower St. Lawrence Seismic Zone.

APPENDIX A

SEISMOGRAPH STATION CODE ABBREVIATIONS

Station codes are the standard three-letter codes used in some of the figures and in the appendices. Old codes (given in brackets) are the informal two-letter codes formerly used by the Dominion Observatory and are as used on the epicentre cards in Appendix C.

CANADIAN STATION CODES

FBC	Frobisher Bay, N.W.T.
GWC	Great Whale River, Québec
HAL	Halifax, Nova Scotia (H)
KLC	Kirkland Lake, Ontario (KL)
MNT	Montreal, Québec
OTT	Ottawa, Ontario (O)
RES	Resolute, N.W.T. (RB)
SAS	Saskatoon, Saskatchewan
SBM	Saint Boniface, Manitoba
SCB	Scarborough, Ontario
SCH	Schefferville, Québec
SFA	Seven Falls, Québec (SF)
SHF	Shawinigan Falls, Québec (SF)
SIC	Sept-Îles, Québec
STJ	St. John's, Newfoundland
TNT	Toronto, Ontario
VIC	Victoria, British Columbia

AMERICAN STATION CODES

BNH	Berlin, New Hampshire
CBM	Caribou, Maine
EMM	East Machias, Maine
FOR	Fordham, New York
HRV	Harvard, Maine
MIM	Milo, Maine
MRG	Morgantown, West Virginia
WES	Weston, Massachusettts

APPENDIX B

EXAMPLE CALCULATION OF TIME CORRECTION FOR SEVEN FALLS

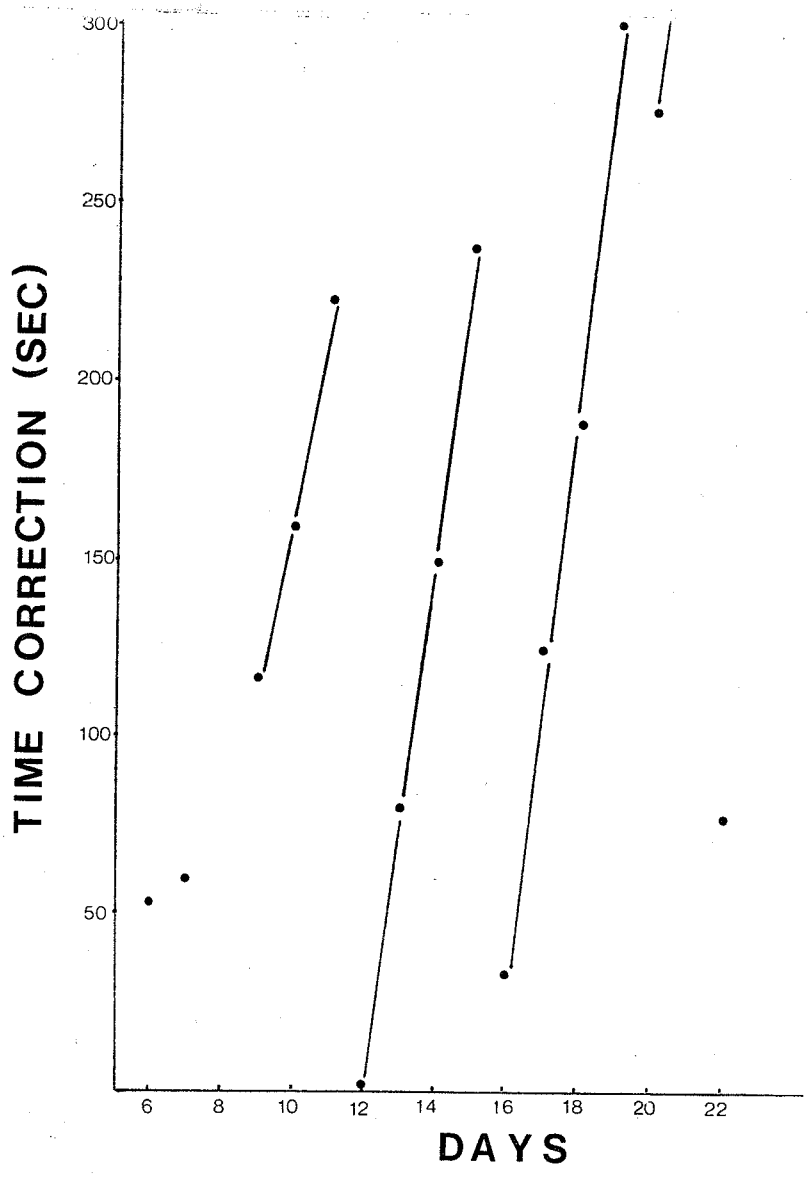
A problem with the time correction was often indicated by residuals of the same magnitude and sign on all phases read at a specific station. The station at Seven Falls (SFA) seems to have had particular problems, as was noticed in particular for the September 14, 1953 earthquake.

Records from the week before and the week after were examined to determine if the loss of time was a linear function (see table below). On the following page is a graph of the time correction plotted against the number of days. Where the lines break, the clock was reset. Although the lines appear linear, they are not exactly parallel, and it was impossible to determine the exact slope of the line. If the slope were changed very slightly, it could have a significant effect on the interpolated time correction. In fact, the time correction at 22:53 on the 14th, the time of the earthquake, could have been inaccurate to plus or minus ten seconds. Thus an arbitrary additional time correction of - 9 sec was added to the predicted one, because it resulted in the lowest residuals for Seven Falls and the other stations.

Top Date 1953	Time Correction (sec)
Sept. 6	53
7	60 (?)
8	?
9	126
10	159
11	222
12	2
13	80
14	149
15	237
16	33
17	123 (?)
18	188
19	300 (?)
20	276
21	360 (?)
22	77

APPENDIX B FIGURE

Time correction for seismograph station SFA for September 1953.



APPENDIX C

DOMINION OBSERVATORY, OTTAWA, EPICENTRE CARDS 1930 - 1963

Before 1961, phase arrival times were written on epicentre cards, and these cards contain the best indication of the data used in the early epicentre determinations. The phases were originally read from the seismograms by E. A. Hodgson (and others) and usually published in the mimeograph (later bound) Canadian Bulletins. In some cases the original seismograms have been lost, and so the cards contain information not available elsewhere.

In addition to the original data, these cards have had amplitude and period data and additional arrival times added, and phases re-interpreted by Canadian seismologist W. E. T. Smith, who re-read the seismograms and relocated many of the early earthquakes. The alterations are in a different script from the original entries, and are in red pencil on the original cards, which were written in ink. Where we re-read the seismograms we found that Smith's re-evaluated phase arrival times (which are not available anywhere else) were generally very good.

30

364 not avail

SHWA	SPWA	Oct 8 1930
8-01-10+0-2.5 D	8-01-10+0-05 D	- 2 ne Str Rep

Felt at Amiere Bersimis & pairs on N. Shore ... to ... Chan SH.

H = 01 08 41

→ 48°56'N 68°42'W Ref Q1 ±500 km

(Bersimis ...)

M = 3.9

S1 = Δ = 260 meas.

e 01 09 31

01 09 44 50 46

S 01 09 54

S 01 09 @ 0.3 sec

Mox 0.9

ML = 3.9

Ref: Q1 52

38

443, pen

Range 0-140	Local Earthquake	Date 17/5/38
Earthquake No: 15-9	Map No:	NESA No:
Ottawa H = 18 31 5-2	H = 18 31 55 Shawinigan	H = 18 3? Seven Falls
Δ ≈ 735 km	Δ ≈ 480 km	Δ ≈ 300 km
	eSn 33 41	e 02
eS1 18 35 22	eS1 18 34 10	eS1 18 33 19
F - 18 35 29	F - 18 35	i - 18 33 24
		F - 34.4
Mox 3.5 mm @ 0.4	mox 0.8 @ 1.0	Mox 1.4 @ 0.3
4.5	4.6	M = 4.2

Not well located but certainly somewhere roughly in line joining the stns.

Nearby quake. Ottawa H = 18:32 - 0

49°N ± 1° 68°W ± 1.5

Possibly in the St Lawrence River in the Baie Comeau - Matane area ML = 4.6 (?)

503 Pen N253 O

Range 0-140 Local Earthquake Date 11/8/42

Earthquake No; 374

✓ Ottawa

P = 11 05 13

Δ = 760

ePn 11 06 51

i(Sn) 11 08 13

iS 11 08 46

F - 11 13 1

Max 2.5@0.3

M - 4.4

✓ Shawinigan

Δ = 495

e 11 07 18

(Sn) 11 07 33

e - 11 07.2

F - 11 09

Max 0.5@0.8

M - 4.5

P = 11 05 13

49°13'N ± 25', 67°24'W ± 30'

✓ Seven Falls

Δ = 350

ePn 11 06 01

e 11 07 51

e 11 07 55 ?

F - 11 10

Max 0.7@0.6 sec

M - 4.2

Nearby quake: Ottawa.

Also the St Lawrence River about 15 miles SE of Godbout. Que. ML - 4.4

✓ Weston

eSn - 11 09 00 ?

Δ - 810

520 300 – 400
~~Range~~ 500 – 750
Earthquake No; 101
Ottawa Δ = 790km
Sheet changed when sheet started.
~~Sm 47.41~~
~~Pg~~ e 12 47 46
~~Lg~~ – 12 47 53
~~Lg~~ – 12 48 13
iS? – 12 48 18
F – 12 53
dist. = 786 km (488 mi.) meas.
Mox 20 @ 0.4 sec
M = 5.3
about 20 miles NNW of Rivière-Pentecôte Que.
49°55'N ± 20, 67°26'W ± 03'

B3 N2 53
Local Earthquake
Map No;
Shawinigan 37
~~H = 12 44 43~~
Δ – ~~5-40~~ 5-50
~~Pg~~ – 12 45 59
~~Pn~~ – 12 46 04
Sm – 12 46 41
~~Sg~~ – 12 46 57
~~Sn~~ – 12 47 12
F – 12 57
Mox 6.7 @ 1.0 M = 5.8
H = 12 44 37.1

Date 9/14/44
NESA No;
Seven Falls
H – 12 44 37.5
Δ – 395
Pm – 12 45 32
(Pg) – 12 45 38.5
Sm – 12 46 14
~~Sn~~ – 12 46 29.5
F – 12 53
Mox 5 mm @ 7.
M = 5.2
ML = 5.4

Fordham
e – 12 49 32 Δ 1130 km
~~Sn~~ 49 56
dist. ~~= 1,099~~ (638 mi.) meas.
NESA gives 49°5' N
67°.2 W
Near mouth of St. Lawrence River.

Weston H = 12 44 37
Pm – 12 46 28.5
~~Pg~~ – 46 43
~~Pg~~ – 46 49
~~Pn~~ – 46 59
Sm – 47 54
~~Sg~~ – 48 07
~~Sg~~ – 48 22
(~~Sn~~) 48 49
~~dist. = 855 km. (531 mi.)~~
~~H = 12 44.66~~
Δ 780

523 300-400 B5 N253 O
Range 400-500 Local Earthquake Date 23/6/44
Earthquake No; 193 Map No; NESA No; 525

√Ottawa used mean H	√Shawinigan	√Seven Falls
Δ=760	H - 6 ~~33~~ 37 55	H - 6 ~~38~~
	Δ - ~~460~~ 485	Δ - 305
iP 6 ~~41~~ 39 32	Pn 6 39 02.5	Pn - 6 38 42
F - 6 43	P* - 6 39 14.5	P* - 6 38 48
one end of sheet blackened so that there could nothing be seen.	Sn - 6 39 57	Sn - 6 39 55
	~~S2 - 6 40 05~~	SA - 6 39 30
	S* - 6 40 12	Max 6mm @ ?
	F - 6 51 possibly 16	M = 4.9

Max 2.4mm @ 1.0 m = 5.2
H = 06 37 52.5
49°25'N ± 20' 67°45'W ± 30 over
About 10 miles NW of Gallout, Que. ML = 5.1

√Weston used mean H

eP* - 06 39 39.5
iSn - 40 59
~~iS~~ - 41 10
~~e~~ - 41 39
iS* - 48
iL - 42 40 Δ=830
Dist. = ~~784 km.~~ (487.2 mi.)
H = 06 38.0
ca. 49°N., 67°50'W.

44c

531 53 0

Range Local Earthquake Date 14/10/44

Earthquake No; 398 Map No; NESA No;

U Ottawa H = 13 26 17 Shawinigan U Seven Falls

Δ = 7.5° Δ = 5.00 Δ = 320

S 13 29 34 S 13 28 38 S 13 27 47

P 13 29 07 13 28+0 04V WA. 13 28+0 01V

S 13 29 47 0.2V

Mop 2.5 @ 0.4 Mop 0.5 @ 0.6 Mop 0.6 @ 0.8 sec

M = 4.3 M = 4.4 M = 4.0

H = 13 26 17

48.5° N ± 1°, 67.0° W ± 2°

0 = the mouth of the St Lawrence River

ML = 4.2

541 220–300
400–500
Range 500–750
Earthquake No; 15

B5 N253

Local Earthquake; Date 17/1/46
Map No; SHcan -1:30; NESA No;

Ottawa	Shawinigan	Seven Falls
H – 8 04 54	H – 8 04 54 mean	H – 8 04 54 × 5:15.0
Δ – ~~685~~ 695 km.	Δ – 440	Δ – ~~300~~
Pn – 8 06 25	~~P~~ – 8 06 00	Pn – 8 05 36
Sn – 8 07 37.5	iSn 8 06 53.5	Sn – 8 06 06
S1 – 8 08 10	S1 – 8 06 58	S1 – 8 06 20
F – 8 11	F – 8 09	F – 8 09
Max 4.8 mm @ 0.4.	Max 0.6 @ 0.9	Max 1.2 @ ?
M = 4.3	M = 4.4	M = 4.1

T = 08 04 54.0
about 30 miles N W of Baie Comeau.
NESA gives ø = 49.4 N. ± .3
λ = 68.7 W. ± .3
ML = 4.3

85
131
54

Weston

eP₂ 08 06 53
eP 07 02?
eSn – 07 53
(iS₂) – 08 06
iS₂ – 08 18
iS₁ – 08 42

dist. = ~~800~~ km. (497 mi) 810 km

H = 08 04 54 used mean of others.

08 42
04 54
3 48

04 56

N.ESA gives 49.4 N., 68.7 W.

Southwest Saguenay County, Canada

562 220-300 400-500 Range 750-1000 — Local Earthquake — Date 16/11/48

Earthquake No; 28 — Map No; — NESA No;

✓ Ottawa
H - 6 ~~03.5~~ 02 56
Δ - ~~780~~ 750 km
~~P_2 - 6 05 16.5~~
~~P_1 - 6 05 40~~
~~(Sn) - 6 05 48.5~~
S_1 - 6 06 22
~~S_2 - 6 06 46~~
~~S_1 - 6 07 12~~
~~F - 6 09.5~~
~~max 2.5 mm @ 0.5 sec~~
M = 4.4

✓ Shawinigan
H ~~- 6 03.2~~
Δ - 460 km nearer / more northerly
P_1 - 6 04 ~~23.4~~
~~e - 6 04 56.5~~
S_1 - 6 05 00 V
~~S_2 - 6 05 13.5~~
~~e - 6 05 27~~
F - 6 08
~~max 0.4 mm @ 0.8 sec~~
M = 4.2

✓ Seven Falls
H - 6 ~~02~~ 02 56
Δ - ~~250~~ 340 km
P_1 - 6 03 50.5 ✓
P_2 - 6 03 54.5
~~S_3 - 6 04 14.8~~
S_2 - 6 04 19 ✓
S_1 - 6 04 32 V
F - 6 07
~~max 0.5 @ 0.7 sec~~

OVER

Epicentre probably east of the Saguenay River and north of the St. Laurence River.

Weston
Sn 06 06 12
~~Se~~ 0643
S_1 0700
Dist ~~100~~ km
875 km

About 65 miles NW of Baie Comeau
per
H = 06 02 56
50.0°N ± 1.0° 69.0°W ± 1.0°
ML = 4.3

58 29/50 O

	e	09	16	14	B5 N2 S3
	(Sn)	09	16	23.0	max @0.5 Δ=775 M=5.0
	~~iZ~~	~~09~~	~~16~~	~~31.5~~	
	~~eZ~~	~~09~~	~~16~~	~~37.5~~	
	SZ	09	17	13	
SF	Pn	09	14	24.5	H Δ = 365 km.
H=09.13.33	P1	09	14	32.5	
	Sn	09	14	59	01
	~~S2~~	~~09~~	~~15~~	~~09.4~~	
	S1	09	15	16.5	max 1.3 @0.5 M=4.5
	~~e~~	~~09~~	~~15~~	~~20.5~~	
	~~e~~	~~09~~	~~15~~	~~31~~	
SH	e	09	15	16	
	e S.M	09	15	30.5	Δ = 505 km
	~~e~~	~~09~~	~~15~~	~~46.5~~	
	e S1	09	15	56.0	max 1.4 @0.7 M=4.9
	~~e~~	~~09~~	~~16~~	~~00~~	
	~~e S1~~	~~09~~	~~16~~	~~04.0~~	

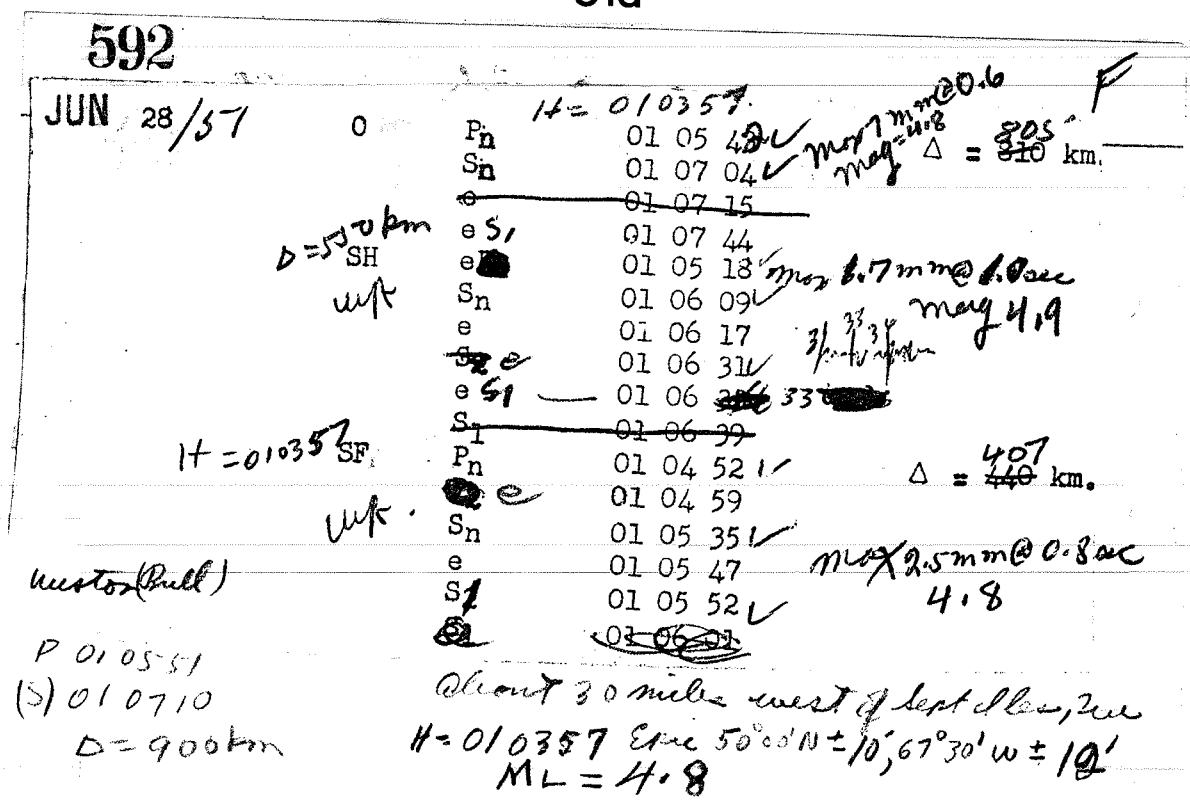
Those northern eq with mean had no readings

On Dec Southwestern prov Jul

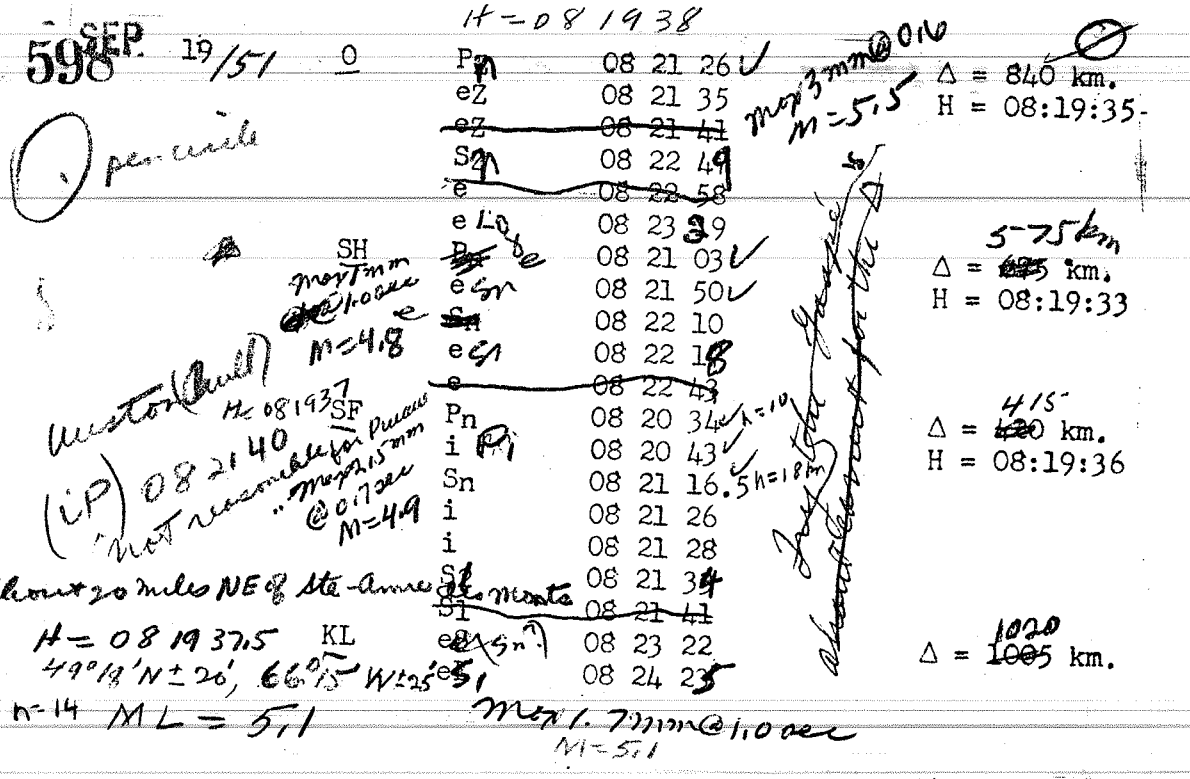
H=091333 49.9N ± 1.0, 68.1W ± 1.0 ML = 4.8

Rese says ~~possibly at 46.5N, 67.5W data not ...~~

51a


592
JUN 28/57
0
H = 010357
Pn 01 05 42
Sn 01 07 04
e 01 07 15
e S1 01 07 44
e 01 05 18
Sn 01 06 09
e 01 06 17
e 01 06 31
e S1 01 06 33
S1 01 06 39
Pn 01 04 52
e 01 04 59
Sn 01 05 35
e 01 05 47
S1 01 05 52
e 01 06 01
mag 4.9
Δ = 407 km.
mag 4.8
Weston (Bull)
P 01 05 51
(S) 01 07 10
Δ = 900 km
About 30 miles west of Ste Agathe, Que
H = 010357 Epic 50°00'N ± 10', 67°30'W ± 12'
ML = 4.8

51b


598 SEP 19/57
0
H = 08 19 38
Pn 08 21 26
eZ 08 21 35
eZ 08 21 41
Sn 08 22 49
e 08 22 58
e Lg 08 23 39
Pn 08 21 03
e Sn 08 21 50
Sn 08 22 10
e S1 08 22 18
e 08 22 43
Pn 08 20 34
i 08 20 43
Sn 08 21 16.5
i 08 21 26
i 08 21 28
S1 08 21 34
S1 08 21 41
e Sn 08 23 22
e S1 08 24 25
mag 3mm@0.1 M = 5.5
Δ = 840 km.
H = 08:19:35
5-75 km
Δ = 825 km.
H = 08:19:33
415
Δ = 420 km.
H = 08:19:36
1020
Δ = 1005 km.
SH
M = 4.8
Weston (Bull)
H = 081937 SF
(iP) 08 21 40
M = 4.9
About 20 miles NE of Ste-Anne de Monts
H = 08 19 37.5 KL
49°18'N ± 20', 66°15'W ± 25'
n = 14 ML = 5.1
Max 1.7mm@1.0 sec
M = 5.1

53a

SF 624	ePn	09 59 32.0	Δ = ~~477~~ 420 km. H=5837
	i	09 59 38.0	Max 5 mm @ 0.4 sec M=5.3
	e	09 59 42.0	
	i	09 59 51.0	
	Sn Lg	10 00 17.0 00 36	
H	iPn	09 59 46	Δ = ~~582~~ 525 km. H=5 8 37
	eSn	10 00 39	max 1.0 mm @ 1.0 sec LPZ Ben
	e	10 00 55	M=4.9
	Sl	10 01 09	
SH	ePn	09 59 52.6	Δ = ~~633~~ 575 km. H= 58'37"
	e	10 00 02.6	Gaspe Peninsula Quebec; felt
	e	10 00 14.6	Our epicentre
	e	10 00 25.6	~~49° 42'~~ N 49°04'N ± 15
	eSn	10 00 ~~50.6~~ 52	~~65° 38'~~ W 66°00'W ± 15
	i	10 01 06.6	H = ~~09 58 29~~ H=09 58 36.6
	Sl	10 01 ~~13.6~~ 21	
O	iPn	10 00 24	Δ = ~~894~~ km. 835 km H=5 8' 37"
	iSn Lg	10 01 48 02 29	max Ben 23 mm @ 0.4 sec M=5.4
KL	ePn	10 00 44	Δ = ~~1027~~ 1075 km. H=58 34'
	eSl	10 03 21 02 22	max 4.5 mm @ 0.5 sec M=5.7
RB	e	10 10.3	
	i	10 13 05 d	

JAN 24 1953

SH: Max 2.1 mm @ 0.5 sec M = 5.3

M=5.3

U2

F

Felt in Gaspe Pen... also 10 miles south of Matapedia Que.

53b

627 SEP 14 1953 (Gillespie's Watertown — ... of desk near door.) — Special writeup — ... — Gaspe

U.T.	N.Lat	W.Long	I	Centre
22:52:57.3	49.8 ±0.5	65.2 ±0.5	Mag 5.1	

SF (WAEW)	ePn	22 54 08? (H = 22 52 58)	SH	e (H, used mean)	22 54 28
	e	27?		e	54 36
	Sn	57?		eSn	55 21
	e	55 13?		e	37
	eLg	22		eLg	54
H	ePn (H 52 58)	54 08		ePn (H)	54 52 (52 56)
	e	36		iSn	56 21
	e	55		Lg	57 08
	Sn	55 00	KL	e(P)	55 15
				eSn (Hand mean)	56 55
				eS1	57 4~~8~~ 50

SF: max 2.0 mm @ 0.7 sec; Δ=510 km Mag 5.1

SH: Δ = 630 km, max 1.0 mm @ 0.5 sec, Mag 5.1

H: Δ 510, Mag 4.9; max 13 mm @ 0.5 sec unrel.

Δ = ~~7??~~ 895 km, max 9 mm @ 0.5 sec, Mag 5.1

KL = 1,040 km, max 2.5 mm @ 0.8 sec, Mag 5.3

Note:- Coords to nearest ½ degree and ~~...~~
~~...~~
~~...e(P) at SH ... with other data.~~

EARTHQUAKES OF EASTERN CANADA

No. 632 *H = 21 04 29.7 Date: Jan. 10, 1954. F

**Epic. Coords.: φ = 49° 10' N ± 15'; λ = 68° 14' W ± 20';

h = km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 3.9

Location: In the Saint Lawrence River about four miles south of Baie-Comeau, Que.

Felt:

Bibliography:

Note:

*Local time prior to 1928. U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM SEISMOGRAMS	
Ottawa SPZ Ben. Δ = 703 km. iS, 21 07 48 Max 1.0 mm @ 0.8 sec Mag. = 3.9	Note:- An alternative solution was at 41°06'N, 66°55'W in New Brunswick East Halifax iPz Bennioff supplied negative evidence in support of the more distant (from Halifax) alternative, which was chosen.
Seven Falls SPZ Ben. H = 21 04 29.7 Δ = 297 km) e 21 05 15 iP, 21 05 17 iS, 21 05 53 Max 2.5 mm @ 0.6 sec Mag. = 3.85	

EARTHQUAKES OF EASTERN CANADA

No. 643 *H = 01 29 53 Date: Sept. 8, 1954.

**~~Epic. Coords.~~: φ = 49.02 ; N ± 15 ; λ = 68.22 ; W ± 17 ;

h = 18 km. M. M. S. I$_o$ = ( ); G.-R. Mag. M$_L$ = 4.3

~~Location:~~ In the St. Lawrence River about 15 miles SW of Baie-Comeau, Que.

~~Felt:~~

~~Bibliography:~~ Mounted in snap hook.

~~Note:~~

*~~Local time prior to 1928. U. T. subsequently.~~

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION	OBTAINED FROM	SEISMOGRAMS
Halifax SPZ Benioff Δ = 610 km e Sn 01 32 15 Lg 01 32 39.5 Max tiny	Kirkland Lake SPZ Sprengnether Δ = 866 km Lg 01 33 58 Max tiny	WAEW May tiny. Shawinigan Falls (from Bulletin) Δ = 430 km S 01 31 53 e 01 32 31 e 01 32 38
Ottawa SPZ Benioff Δ = 688 km e 01 32 37 Lg 01 33 06 Max 3.5 mm @ 0.5 sec Mag. = 4.3	Seven Falls SPZ Benioff WAEW H = 01 29 53 Δ = 280 km Pn 01 30 33.0 h = 16 km P 01 30 37.5 Sn 01 31 03.5 h = 20 km S 01 31 11.5 Ben. uncalibrated	Note: - SF timed by comparing the two records since there were no minute marks on the Ben.

EARTHQUAKES OF EASTERN CANADA

No. 678 *H = 12 51 38.5 Date: Aug. 3, 1956
(assumed 18 for purpose of duration.)

**Epic. Coords.: φ = 49°25' N ± 12'; λ = 66° 10' W ± 18';

h = km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 4.1

Location: In the St. Lawrence River about 55 miles south of Septs-Iles, Que.

Felt:

Bibliography: MOUNTED IN SCRAP BOOK

Note: First shock of at least two (possibly four) occurring in a span of about 40 sec. (See notes on back of this and the following earthquake cards.)

*~~Local time prior to 1928.~~ U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM SEISMOGRAMS		
Halifax SPZ Benioff H = 12 51 38 Δ = 565 km iPn 12 52 52.8 Ⓐ i 12 53 01 eSn 12 53 51.3 iS1 12 54 16.8 Max 1.7 mm @ 0.4 sec Mag. = 3.7	Δ = 687 km S1 12 54 52.4 Max 2.3 mm @ 0.5 sec Mag. = Uncalibrated.	Max 1.8 mm @ 0.7 sec (Benioff) Uncalibrated Max 0.3 mm @ 0.8 sec (WAEW) Mag. = 4.0
Kirkland Lake (SPZ Benioff) Δ = 1020 km (Sn) 12 55 31 S1 12 56 26 Max 0.4 mm @ 0.8 sec Mag. = 4.6	Ottawa SPZ Benioff Δ = 816 km S1 12 55 29 Max 2 mm @ 0.4 sec Mag. = 4.3	Shawinigan Falls SPZ Willm. & WANS Δ = 590 km S1 12 54 (21) Max 1 mm @ 0.5 sec (Willm.) Mag. = 3.9
Montreal SPZ Benioff	Seven Falls WAEW & SPZ Benioff H = 12 51 39 Δ = 450 km Pn 12 52 40 Ⓐ i 12 52 49 Sn 12 53 27 iS1 12 53 46 Ⓐ i 12 53 55	Note: (See also note on next shock) It is quite possible that phases marked Ⓐ above are associated with another shock nine seconds later. If so there exists some uncertainty as to which of the shocks the computed magnitudes refer, if indeed they were not influenced by both. The various phases could not be scaled with enough regards to confirm the occurrence of 4 shocks in 40 sec.

EARTHQUAKES OF EASTERN CANADA

No. 679 *H = 12 52 08.8 Date: Aug 3, 1956

h assumed 18 for purpose of location.

**Epic. Coords.: φ = 49°25' N ± 12'; λ = 66°10' W ± 18';

h = km. M. M. S. I_0 = ( ); G.-R. Mag. M_L = 4.3

Location: On the St. Lawrence River about 55 miles south of Sept-Iles, Que.

Felt:

Bibliography: MOUNTED IN SCRAP BOOK

Note: This is the second or main shock of at least two or possibly it is the third shock of a series of four shocks occurring in a span of about 40 sec. (See notes on back of this card and card giving data on the previous earthquake)

*Local time prior to 1928. U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM		SEISMOGRAMS
Halifax (SPZ Benioff) H = 12 52 08.5 Δ = 565 km iPn 12 53 22.5 d (A) i 12 53 31.5 Sn obscured iS1 12 54 48 Max 2.6 mm @ 0.4 sec Mag. = 3.9	Ottawa (SPZ Benioff) Δ = 816 km S1 12 55-(5-9.5) max 3.6 mm @ 0.5 sec Mag. = 4.5 Seven Falls (WAEW and SPZ Benioff) H = 12 52 09 Δ = 450 km Pn 12 53 10 (A) i 12 53 19 Sn obscured (A) i 12 54 07 iS1 12 54 16 (A) i 12 54 25 Max 1.5 mm @ 0.6 (Ben) Mag. = Uncalibrated Max 0.4 mm @ 0.6 sec Mag. = 4.2 (WAEW) Shawinigan Falls SPZ Will & WANS	H 12 52 (04) Δ = 590 km Pn 12 53 (2-2) (A) i 12 53 (31) Sn obscured S1 12 54 51 Max 1.3 mm @ 0.9 sec (Will) Mag. = 4.0 NOTE: The note on the previous earthquake applies exactly to this one: i.e. the phase marked (A) might be a separate shock. If there were four shocks in a span of about 40 sec the "Pn" amplitudes on the Halifax record would indicate that they increased in magnitude from first to last.
Kirkland Lake SPZ Lorentzville Δ = 1020 km Sn 12 56 01 S1 12 56 56 Max 0.6 mm @ 0.8 sec Mag. = 4.5		
Montreal (SPZ Ben) Δ = 687 km S1 12 55 23 Max 4.2 mm @ 0.6 sec Mag. Uncalibrated		

EARTHQUAKES OF EASTERN CANADA

No. 682 *H = 14 40 05.5 Date: Oct. 27, 1956

**Epic. Coords.: φ = 48° 15' N ±20'; λ = 69° 00' W ±25';

h = km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 3.4

Location: Near the south shore of the St. Laurence River about 15 miles down stream from Trois-Pistoles, Que.

Felt:

Bibliography:

Note: Has one aftershock about 24 minutes later.

*Local time prior to 1928. U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM		SEISMOGRAMS
Montreal SPZ Benioff Δ = 462 km S, 14 42 16 Max 1.9 mm @ 0.4 sec Mag. = 3.4	Lamont Tucia SPZ Benioff times uncertain. H = 14 39 ~~22 4~~ Δ = 185 km P, 14 40 (02) S, 14 40 (24.3) Max 1.0 mm @ 0.4 sec Mag.: Sensitivity unknown.	S, 14 41 41.5 Max 0.6 mm @ 0.5 sec Mag. = 3.05
Ottawa SPZ Benioff Δ = (558 km) S, 14 42 43.5 Max 1.5 mm @ 0.3 sec Mag. = 3.6	Shawinigan Falls SPZ Willmore H = 14 40 05.5 Δ = 340 km P, 14 41 00.0	This shock did not produce optimum records and the location is therefore less precise than it might have been.

EARTHQUAKES OF EASTERN CANADA

No. 683 *H = 15 03 53 Date: Oct. 27, 1956

**Epic. Coords.: φ = 48° 15' N ±20'; λ = 69° 00' W ±25';

h = km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 3.4

Location: 15 miles downstream from Trois-Pistoles, Que. near the south shore of the St. Lawrence River about

Felt:

Bibliography:

Note: Apparently an aftershock of the earthquake about 24 minutes earlier.

*Local time prior to 1928. U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION	OBTAINED FROM	SEISMOGRAMS
Montreal SPZ Benioff Δ = 457 km S, 15 06 0- Max 1.5 mm @ 0.4 sec Mag. = 3.4	H = 15 03 ~~15 05~~ Δ = 185 km P, 15 03 (51.5) S, 15 04 (14.0) Max, 1 mm @ 0.5 sec Mag. = Sensitivity Unknown	This shock did not produce optimum records and the location is therefore less precise than it might have been.
Ottawa SPZ Benioff Δ = (5 70 km) S, 15 06 34 Max 1.5 mm @ 0.4 sec Mag. = 3.6	Shawinigan Falls SPZ Willmore H = 15 03 53 Δ = 340 km P, 15 04 47.5 S, 15 05 29.0 Max 1.0 mm @ 0.7 sec Mag. = 3.1	
Seven Falls SPZ Benioff Times uncertain		

EARTHQUAKES OF EASTERN CANADA

No. 698 *H = 1913 26.5 Date: Oct. 16, 1957

**~~Epic. Coords.~~: φ = 50° 30' N ± 19'; λ = 64° 52' W ± 19';
h assumed 20 km for purpose of determination of epicentre
h = ~~km.~~ M. M. S. I_o = ( ); G.-R. Mag. M_L = 4.8

~~Location:~~ About 20 miles north of Sheldrake, Que.

~~Felt:~~

~~Bibliography:~~

~~Note:~~

*~~Local time prior to 1928. U. T. subsequently.~~
**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM SEISMOGRAMS		
Halifax SP Will. 30 mm/min Δ = 660 km i 19 14 59 i 19 15 20 Sn 19 15 55 Lg 19 16 31 Max 8.0 mm @ 0.8 sec Mag. = 4.7	iPn 19 15 33 iSn 19 17 04 Lg 19 11 55 Max 7.5 mm @ 0.4 sec Mag. = 5.1	iSn 19 15 36.1 Lg 19 16 01 Ben max 10 mm @ 0.7 sec Mag = 4.5 WA max 0.6 mm @ 0.8 sec Mag. = 4.7
Montreal SP Benioff H = 19 13 28 Δ = 840 km iPn 19 15 16.5 d iSn 19 16 34.0 Lg 19 17 19.5 max 7.5 mm @ 0.8 sec Mag = 4.8	Palisades SP Benioff Δ = 1270 km i 19 18 47 i 19 19 06 L 19 19.19 Readings from the Palisades Bulletin	Shawinigan Falls SP & Willmore, WA NS H = 19 13 26.2 Δ = 730 km Pn 19 15-01.2 iSn 19 16 09.7 Lg 19 16 40.7 Willmore dem WA max 0.7 mm @ 0.6 sec Mag. = 5.2
Ottawa SP Benioff H = 19 16 26.0 Δ = 995 km	Seven Falls SP Benioff WA EW H = 19 13 26.0 Δ = 575 km iPn 19 14 41.5 c i 19 14 49 (Pn) 19 14 57.0	Weston SP Benioff Δ = 1030 km iSn 19 17 14 c Reading from Bulletin and phase assigned during epicentre determination

EARTHQUAKES OF EASTERN CANADA

No. 731 H= 09:32:51.4 Date: Oct. 21, 1958.

P 49.6° ± 0.5° N 68.0° ± 0.5° W h= 13.5 (?) km. Mag.= 4.1

Location: About 30 miles NNE of Baie Comeau, Que.

Felt: Report received of a "fire ball" being seen.

Papers published (if any) followed by the

Instrumental data: Nil

(over)

Ph.	Stn. or Time	A. mm.	P. sec.
Seven Falls (SPZ Ben)			
H —— Δ = 346 km			
S, 09:34:20.7			
Uncalibrated			
Shawinigan Falls (SPZ Ben)			
H —— Δ = 492 km			
i 09:34:47			
S, 09:34:59.2			
Max	1.5	0.5	
Mag. = 3.95			

Ph.	Stn. or Time	A. mm.	P. sec.
Montreal (SPZ Ben)			
H 09:32:49.9 Δ = 622 km			
Pn 09:34:11.7 h = 16 km			
P, 09:34:29.8			
Sn 09:35:11.5 h = 13 km			
S, 09:35:39			
Uncalibrated			
Ottawa (SPZ Ben)			
H 09:32:53 Δ = 745 km			
Pn 09:34:31 h = 15 km			
Sn 09:35:43 h = 10 km			

Ph.	Stn. or Time	A. mm.	P. sec.
S, 09:36:13			
Max	2.5	0.3	
Mag. = 4.3			

Note: This shock was not well recorded and lies in line with the stations hence the rather large uncertainty in the location and in h.

EARTHQUAKES OF EASTERN CANADA

No. 740 *H = 13 52 49.3 Date: Aug. 1, 1959.

**Epic. Coords.: φ = 48°25' N ±12'; λ = 68°19' W ±12';

h = km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 4.1

Location: About 10 miles east of Rimouski, Que.

Felt:

Bibliography:

Note:

*Local time prior to 1928. U. T. subsequently.
**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM SEISMOGRAMS		
Halifax SPZ Willmore H = 13 52 48 Δ = 555 km Pn 13 54 04 S, 13 55 26 Max 1.4 mm @ 0.5 sec Mag. = 4.1	Ottawa SPZ Benioff Δ = 656 km S, 13 55 51 Max 4.0 mm @ 0.4 sec Mag. = 4.3	Shawinigan Falls SPZ Willmore H = 13 52 51.0 Δ = 392 Pn 13 53 46.5 S, 13 54 41 Max 4.2 mm @ 0.9 sec Mag. = 3.9
Montreal SP Benioff H = 13 52 48.3 Δ = 520 km Pn 13 53 59.3 Sn 13 54 51 i 13 55 12.5 S, 13 55 14 Max 7.5 mm @ 0.4 sec Mag. = 4.2	Seven Falls SP Benioff H = 13 52 49.5 Δ = 235 km Pn 13 53 26.0 i 13 53 30.5 i 13 53 51.5 S, 13 53 57.5 Uncalibrated	Note: Depth not indicated by records

EARTHQUAKES OF EASTERN CANADA

No. 742 *H = 01 36 30.2 Date: Sept. 25, 1959

**Epic. Coords.: φ = 50° 11 ' N ±35 '; λ = 68° 12 ' W ±35 ';

h = km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 3.9

Location: Between the Manicouagan and Toulnustouc Rivers about 40 miles above their junction in the Province of Quebec.

Felt:

Bibliography:

Note:

*~~Local time prior to 1928.~~ U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM SEISMOGRAMS	
Montreal SPZ Benioff H = 01 36 30 Δ = 660 km e 01 38 55 iSn 01 39 02 iS 01 39 36.5 Max 2.6 mm @ 0.6 sec Mag. = 4.0	Seven Falls sp&b H = 01 36 27.5 Δ = 388 km iSn 01 38 02.6 S 01 38 17 Max 1.6 mm @ 0.4 sec Mag. = 3.5
Ottawa SPZ Benioff H = 01 36 32.8 Δ = 770 km eSn 01 39 28 S 01 40 10 Max 2.0 mm @ 0.4 sec Mag 4.1	Shawinigan Falls SPZ Willmore H = 01 36 30.5 Δ = 525 km eSn 01 38 34.5 S 01 38 58.5 Max 1.5 mm @ 0.7 sec Mag. = 3.9

EARTHQUAKES OF EASTERN CANADA

No. *H = 22 43 44.2 Date: July 5, 1961

**Epic. Coords.: φ = 50° 15' N ± 15'; λ = 66° 47' W ± 10'; assumed?

h = 20 km. M. M. S. I_o = ( ); G.-R. Mag. M_L = 5.0

Location: About 17 miles W by N of Sept-Iles Inc.

Felt: Generally in Sept-Iles but most strongly in the N.W. portion also at Moisie Port Cartier and along the Moisie river and up ~~the railway to Sika (mile 52) but not beyond. It~~ was not felt at Matane on the south shore of the river.

Bibliography: See SEIS. SERIES 1961 -

Note: Questionaires were distributed but population is so far from randomly distributed making epicentral map impractical.

*Local time prior to 1928. U. T. subsequently.

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION OBTAINED FROM		SEISMOGRAMS
Halifax SPZ Will. D.G. H = 22 43 44.3 Δ = 665 km iPn 22 45 11.0 d i 22 45 20.3 eSn 22 46 14.3 eLg 22 46 45 (?) Max 2.7 mm @ 0.5 sec from regular Will. Mag. = 4.6	i 22 45 37.1 iSn 22 46 28.5 Lg 22 47 02 Max 10 mm @ 0.4 sec Mag. = 5.2	Shawinigan Falls SPZ Willmore SPNS Wood Lindros H = 22 43 44.2 Δ = 608 km iPn 22 45 04.0 iSn 22 46 00.6 Lg 22 46 29.1 Max 7.0 mm @ 0.4 sec Will. Mag. 5.0 Max 1.2 mm @ 0.4 sec W.A. Mag. = 5.2 Note: Solution based on an assumed depth of 20 km.
Montreal SPEW Benioff H = 22 43 44.2 Δ = 736 km ePn 22 45 19.6 i 22 45 28.8	Ottawa SPEW Will H = 22 43 44.2 Δ = 870 km ePn 22 45 36 iSn 22 46 56.2 S, eLg 22 47 40 (?) Max 8.0 mm @ 0.6 sec Mag. = 4.9	

EARTHQUAKES OF EASTERN CANADA

No. *H = 00 58 32 Date: dec 15, 1962

**~~Epic.~~ Coords.: φ = 50° 12' N ± — '; λ = 66° 23' W ± — ';

h = ~~km.~~ M. M. S. I_0 = IV ( ); G.-R. Mag. M_L = 4.6

~~Location:~~ Probably 15 miles or more from Sept-Iles.

~~Felt:~~ Sept-Iles, Que

~~Bibliography:~~

~~Note:~~ Felt report telephoned to Father Auist by the town manager. Said "residences cracked".

*~~Local time prior to 1928. U. T. subsequently.~~

**When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

INFORMATION	OBTAINED FROM	SEISMOGRAMS
Montreal H = 00 58 32 Δ = 715 km apros Pn 01 00 05 EW Sn 01 01 13 NS Lg 01 01 50 EW Max 9 mm (2) @ 0.4 sec Mag. = 4.6	above plus a felt report from Sept-Iles. The town manager called Father Auist to say that the shock was felt and that "residences cracked"	
No other record. Located from the		

EARTHQUAKES OF EASTERN CANADA

No. *H = 06:29:34.4 Date: Oct. 19 1963

**Epic. Coords. OR: φ = 50.0° N ± 0.5'; λ = 67.8° W ± 0.1';

h = km. M.M.S.I. = ; G.-R. Mag. M_L = 2.9

Location OR Mouth of St. Lawrence about 20 miles west of Anticosti Island.

Felt

Bibliography:

Note:

* Local time prior to 1928. U.T. subsequently.

** When "Epic." is crossed out, the "Coords." refer to the place named after "Felt:". (over)

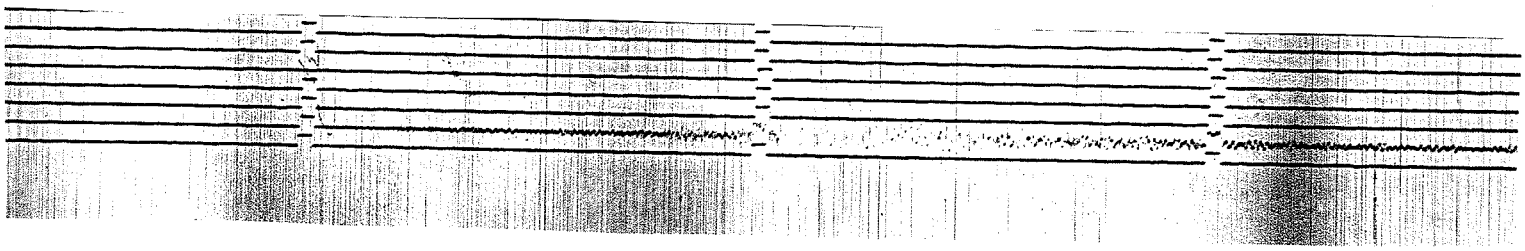
INFORMATION	OBTAINED FROM	SEISMOGRAMS
Sept Iles H = 0629 34.4 Δ = 105 km P, 06 29 51.2 S, 06 30 04 Max 13 mm @ 0.4 sec Mag = 2.5	Mag. = 3.3	
Schefferville Δ = 535 km (P,) 063100.5 S, 063205 Max 1.5 mm @ 0.3		

APPENDIX D

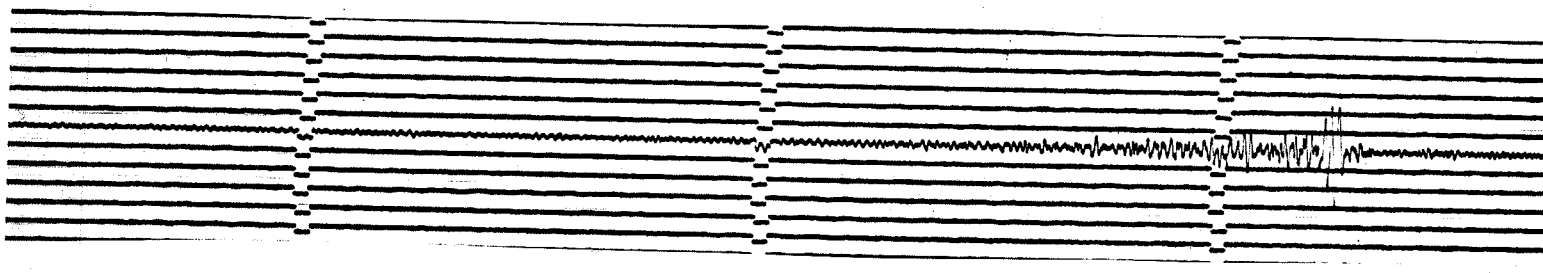
PHOTOCOPIES OF SELECTED SEISMOGRAMS

April 9, 1944

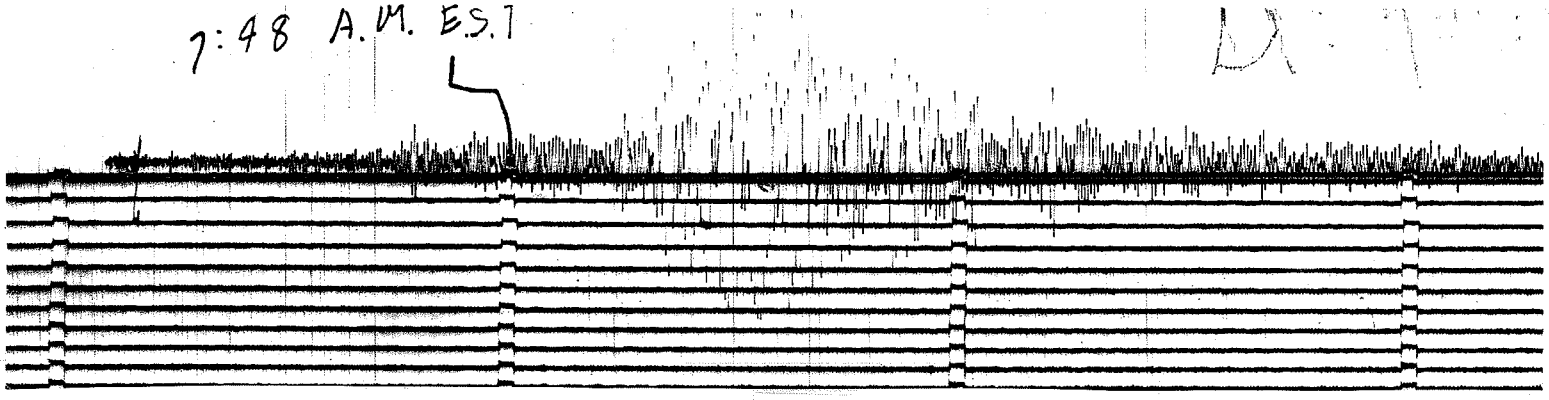
Seven Falls Wood Anderson East-West



Shawinigan Falls Wood Anderson North-South

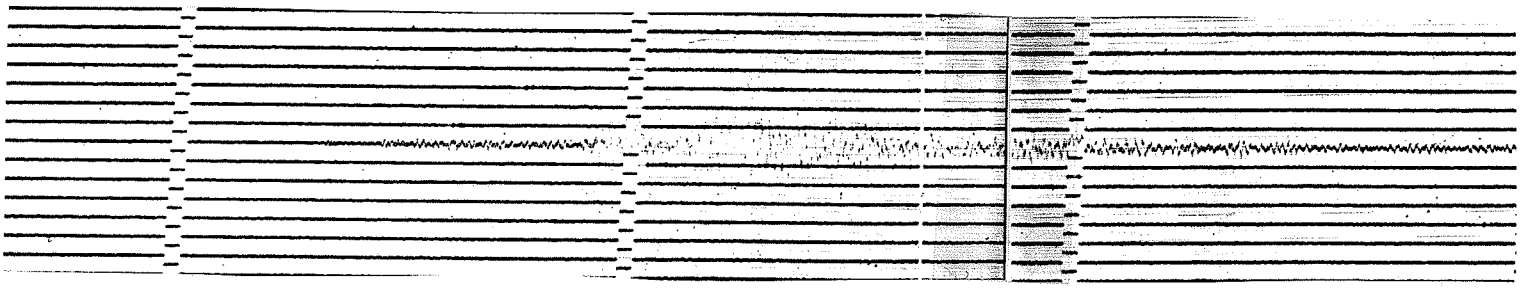


Ottawa Short Period Benioff

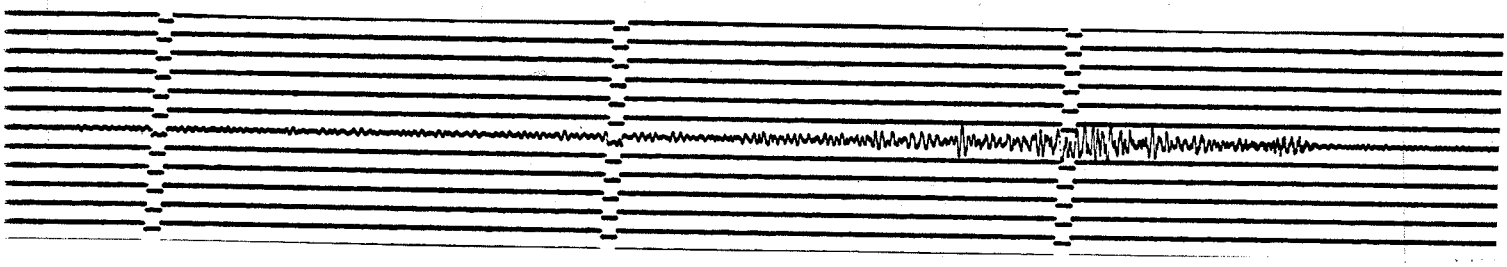


June 23, 1944

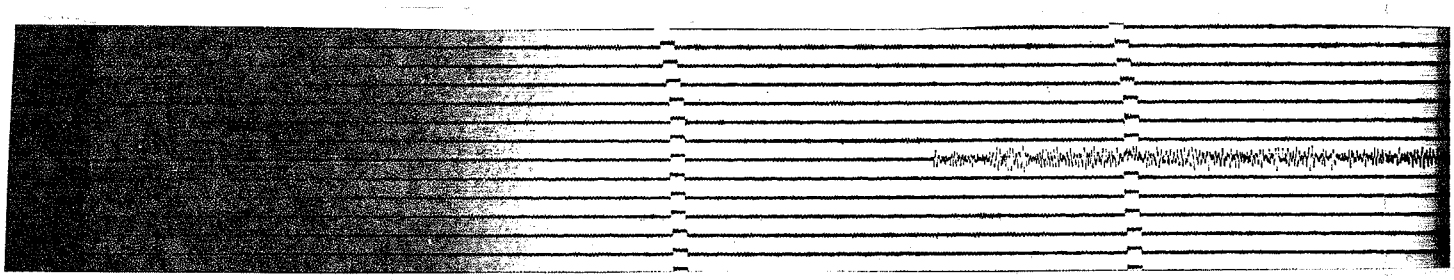
Seven Falls Wood Anderson East-West



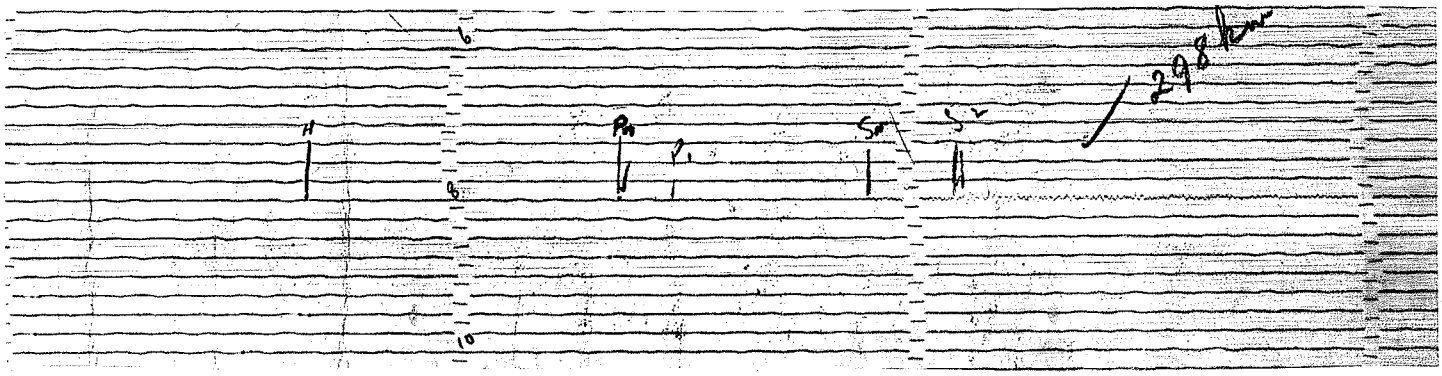
Shawinigan Falls Wood Anderson North-South



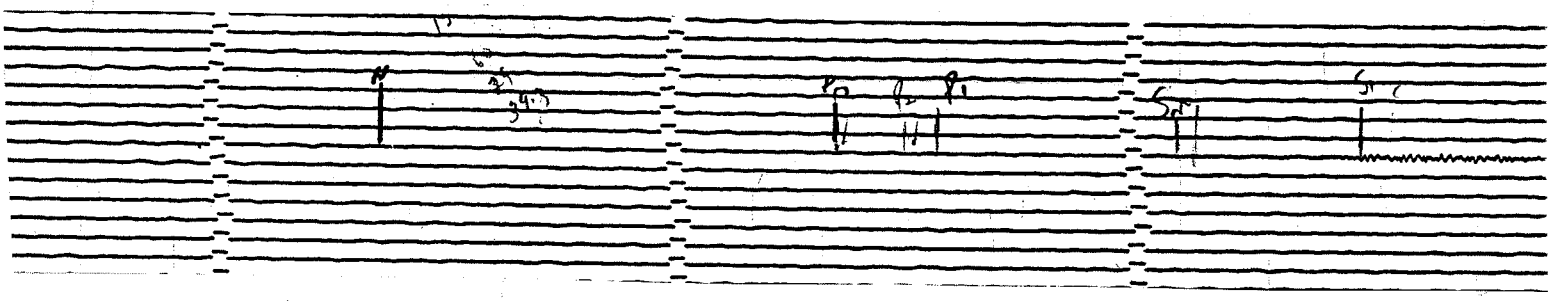
Ottawa Short Period Benioff



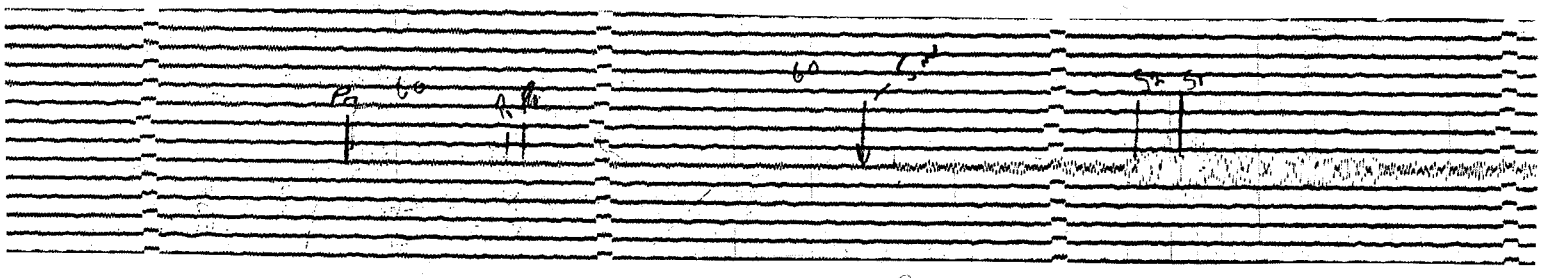
Seven Falls Wood Anderson East-West



Shawinigan Falls Wood Anderson North-South



Ottawa Short Period Benioff



APPENDIX E

DATA AND SOLUTIONS FOR RELOCATED EVENTS

The following earthquake solution records are in the standard Geophysics Division 'PIK' file format (see for example the appendix in Adams et al., 1988, GSC Open File 1892, for a description), and contain full comments with respect to the phases, the epicentre, and previous epicentres for each earthquake. Note: the gaps in the middle of the page are imposed by the Laserprinter.

```
+48.930- 68.700O MN=4.1 0108410 08101930 00.0000.000 0.0  1  2  10.00N218.00   0 1ML=3.9  10  0 3.62
$ FELT AT RIVIERE-BERSIMIS PQ AND POINTS ON THE NORTH SHORE OF THE LOWER ST. LAWRENCE
$ SMITH: EPICENTRE CLOSER TO SFA THAN TO SHF
$ LOCATED BY SMITH AT BERSIMIS PQ
$ SMITH DID NOT ASSESS ACCURACY
$ EPICENTRE IS CONSISTANT WITH DISTANCE FROM SFA                                              #30
$
SFA  3010080108P                  X0931      B0944   B0954   030 2.1 009
SFA   SW 0256KM          219-86   00  859    10 -105 10  207   0008976 39ML41MN
SHF  3010080108P
SHF   SW 0404KM          231 49                                 0000000 00ML00MN
               Z


+48.752- 67.690O MN=3.9 1832037 17051938 00.8110.768 0.4  3  5  41.94 218.00   0 1ML=4.4  20  0 3.62
$ 49.000  -68.000  MN=3.9 CEEF AND SMITH LOCATION
$   SMITH'S ASSESSED ACCURACY +/-1 DEG N +/- 1.5 DEG W
$ AS NOTED BY SMITH, ALMOST IN LINE WITH ALL THE STATIONS
$ A LOWER ST. LAWRENCE EARTHQUAKE, BUT POORLY LOCATED
$                                                                                            #38
SFA  3805171832P                                  B3319   B3324   030 2.1 014
SFA   SW 0296KM          233 49                   10  266 10 -175   0013963 43ML43MN
SHF  3805171832P                                  B3347   B3410   100 1.3 008
SHF   SW 0453KM          239 49                   10 -266 10  101   0003867 46ML41MN
OTT  3805171832P                                          B3522   040 066 035
OTT   SW 0715KM          241 49                           10  075   0000833 44ML38MN
WES  3805171832P                                          090 020 009
WES   SW 0763KM          203 49                             0000314 42ML34MN
               Z


+49.168- 67.022O MN=3.7 1105117 11091942 00.2260.360 0.3  4  6  42.67 218.00   0 1ML=4.4  20  0 3.62
$ 49.220   -67.400  MN=3.7  CEEF AND SMITH LOCATION
$   SMITH'S ASSESSED ACCURACY: +/-25'N +/-30'W
$
SFA  4209111105P  B0601                                   060 2.2 007
SFA   SW 0363KM 10 -081 233 49                            0003332 42ML39MN                   #42
SHF  4209111105P                                  B0733   080 1.9 005
SHF   SW 0519KM          238 49                   10 -224   0002067 45ML39MN
OTT  4209111105P  B0651                 B0813   B0846   050 082 025
OTT   SW 0780KM 10 -162 241 49          10  572 10 -132   0000383 43ML35MN
WES  4209111105P                                  B0900   060 100 025
WES   SW 0825KM          205 49                   10  027   0000262 42ML34MN
               Z


+49.768- 66.857F MN=4.8 1244349 09041944 00.0850.077 0.3  3  8  30.67 218.00   0 1ML=5.5  20  0 3.62
$ CEEF EPICENTRE: 49.92N 67.43W  MN = 4.9  SMITH'S ASSESSED ACCURACY: +\-20'N +\-30'W
$ NESA EPICENTRE: 49.5N  67.2W
$ NESA GIVES NO NEW DATA
$ HAL BOSCH TOO LOW GAIN TO RECORD TRACE
$ ISS BULLETIN INDICATES HARVARD RECORDS ARE AVAILABLE                                       #44a
$ FOR EMERGENT PHASE DOES NOT FIT PN, PG, OR SN ARRIVAL TIMES
$ SMITH READ SHF PHASE AT 4559, REREAD AT 4556 - VERY EMERGENT
$ OTT LG ORIGINALLY READ AT 4813
$ SHF P PHASES VERY WEAK
$ SHF PG ORIGINALLY READ AT 4604
$ SFA TIME CORRECTION = +27.5 SEC
$ SHF TIME CORRECTION = -1 MIN 31 SEC
$ OTT TIME CORRECTION = 0 SEC (ASSUMED)
$ OTT PN PHASE LOST WHILE RECORD WAS BEING CHANGED
$ OTT PHASES READ AS BEST AS POSSIBLE BUT PHASE ARRIVALS NOT DISTINCT
$ OTT MAGNITUDE DATA FROM SP BENIOFF
$ OTT LP BENIOFF: MAX 1.5 MM @ 0.5 SEC WITH 2.6 K GAIN GIVES ML= 5.6, MN = 4.8
$
SFA  4404091244P   4532           X45385     4614    46295  100 1.5  50
SFA   SW 0416KM 10  058 226 49    00 -361    10  099 10 -046   0020944 52ML48MN
SHF  4404091244P  X4556           X46055     4644    4712   100 1.5  67
SHF   SW 0567KM 00  621 233 49    00 -093    10 -108 10  039   0028065 57ML51MN
OTT  4404091244P                             X4743   X4818   040  85 200
OTT   SW 0825KM          237 49              00  301 00 -487   0003696 52ML45MN
WES  4404091244P   46285          4659       4754    X4849   050 100 105      3
WES   SW 0891KM 10 -079 204 49    10  035    10  001 00  796   0001319 50ML41MN
FOR  4404091244P                                    X4956
FOR   SW 1132KM          212 49                     00  820   0000000 00ML00MN
               Z
```

```
+49.217- 67.301F MN=4.7 0637533 23061944 00.1120.117 0.1  4 13  31.40 218.00    0 1ML=5.1  20   0 3.62
$ CEEF EPICENTRE: 49.42N 67.75W  ML = 5.1       SMITH'S ASSESSED ACCURACY +/-25'N +/-20'W
$ NESA EPICENTRE: 49.0N  67.5W
$ NESA BULLETIN GIVES NO NEW DATA
$ HAL BOSCH SHOWS NO RECORD OF TRACE
$ KLC RECORD NOT AVALIABLE                                                                        #44b
$ OTT SP BENIOFF BLACKENED - COULD READ PN.  SN & LG READ FROM LP BENIOFF
$     SN PHASE CHECKED ON SP RECORD USING LIGHT TABLE.
$ TIME CORRECTION ON SFA =  1 MIN 21 SEC
$ TIME CORRECTION ON SHF = -1 MIN 34.5 SEC
$ TIME CORRECTION ON OTT ASSUMED TO BE ZERO
$ OTT MAGNITUDE DATA FROM LP BENIOFF
$ ORIGINAL SFA LG READING USED
$
SFA  4406230637P    3841             3848       3915    3930   100 1.5  60
SFA    SW 0351KM 10 -089 230 49    10 -204    10 -258 10 -042    0025133 51ML47MN
SHF  4406230637P    39025            39145      3951    4012   100 1.6  24
SHF    SW 0505KM 10  184 236 49    10 -036    10  068 10 -093    0009425 51ML46MN
OTT  4406230637P    3932                        4048    4126   050 2.6  13
OTT    SW 0765KM 10 -040 239 49                 10  231 10  121    0006283 54ML47MN
WES  4406230637P    39395                       4059   X4148   060 100 140       3
WES    SW 0821KM 10  024 204 49                 10  133 00  767    0001466 50ML41MN
             Z


+50.247- 68.510O MN=3.7 1326154 14101944 00.0740.063 0.2  4  6  30.46 218.00    0 1ML=4.3  20   0 3.62
$ CEEF EPICENTRE: 48.5N 67.0W  ML = 4.2   SMITH'S ASSESSED ACCURACY +/-1.0 DEG N +/- 2.0 DEG W
$ SMITH PLACED THIS "IN THE MOUTH OF THE ST LAWRENCE RIVER"
$     COORDINATES WOULD FIT BETTER IF HE WROTE DOWN 48.5 BUT MEANT 49.5
$ DATA SPARSE
$ ORIGINAL CANADIAN RECORDS NOT SEEN                                                              #44c
$ WES READ BY JOHN EBEL (17 AUGUST 1988)
$     SPH @ 2937, SPZ @ 2950, END OF LG @ 3046, LG ONSET EMERGENT
$     PHOTOCOPIES OF THE ORIGINAL RECORDS WERE EXAMINED
$     LG PHASE USED BELOW IS TAKEN FROM BOTH HORIZONTALS; SPZ IS EARLIER
$ SFA S TAKEN AS LG BY SMITH, FITS BETTER AS SN
$ EPICENTRE PLACES THIS EARTHQUAKE IN THE MANICOUAGAN VALLEY
$   CLOSE TO EARTHQUAKE ON 480116 AND NORTH OF THE MANIC-3 INDUCED SEISMICITY
$
SFA  4410141326P                                 2747          080 2.7   6
SFA    SW 0387KM          207 49               10 -035           0001745 41ML36MN
SHF  4410141326P                                          2838   060 2.1   5
SHF    SW 0518KM          219 49                        10 -057    0002493 46ML40MN
OTT  4410141326P                                 2907    2947   040  85  25
OTT    SW 0763KM          228 49               10 -028 10  075    0000462 42ML36MN
WES  4410141326P    2811                         2937   X3020   080 074 025       3
WES    S  0901KM 10  004 195 49                 10  042 00 -429    0000265 44ML34MN
             Z


+48.813- 68.266F MN=3.8 0805023 17011946 00.1700.155 0.1  4  9  31.74 218.00    0 1ML=4.2  20   0 3.62
$ CEEF EPICENTRE: 49.4N 68.7W   ML = 4.3    SMITH'S ASSESSED ACCURACY +/-0.3 DEG N +/-0.3 DEG W
$ NESA EPICENTRE: 49.4N 68.7W
$ NESA BULLETIN CHECKED - IMPROVED WESTON DATA
$ SFA AND OTT PN PHASES VERY WEAK                                                                 #46
$ SFA TIME CORRECTION = +5 MIN 13 SEC
$ SHF TIME CORRECTION = -1 MIN 28 SEC
$ SHF PN PHASE AT 0600 IS EMERGENT




$ HAL BOSCH TOO LOW GAIN TO RECORD TRACE
$
SFA  4601170804P  X05375          X0543       0607    0619   060 2.1  12
SFA    SW 0268KM 00 -324 226 49    00 -267    10 -193 10  243    0005984 40ML39MN
SHF  4601170804P    0600                       06435   0658   090 1.6   6
SHF    SW 0421KM 10  063 235 49                10  206 10 -076    0002618 43ML39MN
OTT  4601170804P  X06255                       07380   0808   040  85  45
OTT    SW 0681KM 00 -561 239 49                10  119 10 -260    0000832 43ML37MN
WES  4601170804P                    0702       0753   X0842   050 118 020       3
WES    S  0753KM          200-89    10 -187    10  085 00 1149$  0000213 40ML32MN
             Z


+50.225- 68.654O MN=3.6 0602499 16011948 00.1830.264 0.3  4  9  32.24 218.00    0 1ML=4.3  20   0 3.62
$ 50.000   -69.000  MN=3.7 CEEF AND SMITH LOCATIONS
$ SMITH'S ASSESSED ACCURACY  +/-1.0 DEG N +/-1.0 DEG W
$ OTT - PHASE AT 0516.5 DOESN'T FIT AS PG
$ SHF - ARBITRARY TIME CORRECTION OF 8 SECONDS ASSUMED (NO MIN MARKS ON RECORD)                   #48
$ KLC - VERY SMALL TRACE VISIBLE ON RECORD
$ HAL - BOSCH RECORD EXAMINED WITH GREAT CARE, BUT GAIN TOO LOW FOR TRACE TO BE SEEN.
$ WES - NO DATA AVAILABLE FOR MAGNITUDE DETERMINATION
$ FITTING KLC PUSHES THE EPICENTRE SOUTHEAST TOWARDS THE ST. LAWRENCE RIVER.
$    BUT THIS PRODUCES UNREASONABLY LARGE RESIDUALS ON WESTON
SFA  4801160602P                    B03505     B0419   B0432   070 002 005
SFA    SW 0381KM          206-87    10 -087    10 -144 10 -316    0002244 41ML37MN
SHF  4801160602P              +8.   B0404              B0500   080 002 004
SHF    SW 0510KM          218-88    10 -017            10 -280    0001571 44ML38MN
OTT  4801160602P                                B0540   B0622   050 157 025
OTT    SW 0754KM          227 49                10  016 10  378    0000200 39ML32MN
KLC  4801160602P                                      XB0715   100 9.4 001       3
KLC    W  0861KM          259 49                      00 2727$  0000067 37ML28MN
WES  4801160602P                                B0612   B0700
WES    S  0896KM          194 49                10  195 10  255    0000000 00ML00MN
             Z


+47.877- 64.890F MN=4.3 0913115 29061950 00.0810.116 0.3  5 14  41.69 218.00    0 1ML=4.8  10   0 3.62
$ CEEF EPICENTRE: 49.9N 68.1W H=091333  MN = 4.3  (NORTH SHORE OF ST. LAWRENCE)
$  SMITH'S ASSESSED ACCURACY: +/-1.0 DEG N +/-1.0 DEG W
$ SFA P PHASES VERY POOR
$ SFA TIME CORRECTION = 1 SEC                                                                     #50
$ SHF EMERGENT PHASE AT 1516 DOES NOT FIT AS PN OR PG - VERY WEAK
$ SHF TIME CORRECTION = +20 SEC
$ SHF SMITH READ LG AT 1556 - DOES NOT FIT
$ OTT SMITH READ PN AT 1614 - DOES NOT FIT
$ OTT TIME CORRECTION = 0 SEC (ASSUMED)
$ HAL BOSCH TOO LOW GAIN TO RECORD TRACE
$ KLC RECORD NOT FOUND (MAY NOT EXIST)
$ NESSA BULLETIN CHECKED - HARVARD AND WESTON DATA ADDED
$ SMITH DID NOT HAVE US DATA WHEN HE CHOSE THE EPICENTRE
$ EPICENTRE MOVES TO NEW BRUNSWICK, VICINITY OF CARAQUET
$ K.B.S. BURKE FOUND FELT REPORTS IN NEW BRUNSWICK NEWSPAPERS:
$   FELT AT NEWCASTLE AND OUTLYING MIRAMICHI COMMUNITIES
$     "WOKE SOME"
$   FELT AT MARYSVILLE, NEAR FREDERICTON
$   NO FELT REPORT IN BATHURST NEWSPAPERS
$
SFA  5006290913P                    14245      1459    15165  050 2.1  13
SFA    W  0455KM          262-88    10 -054    10  103 10 -091    0007779 48ML44MN
SHF  5006290913P                               15305   1604   070 1.4  14
```

```
SHF   W  0614KM          259 49                    10 -132 10  263   0008976 55ML47MN
WES  5006290913P   14552            15188          1606    16515  050 118 140
WES   SW 0793KM 10  126 222 49    10 -065     10 -374 10  090   0001491 49ML41MN
HRV  5006290913P   14565                          16093   16525
HRV   SW 0794KM 10  238 224 49                   10 -076 10  152   0000000 00ML00MN
OTT  5006290913P                                  16250   1713   070  63  70
OTT   W  0873KM          256 49                   10 -192 10  011   0000997 49ML40MN
               Z


+49.730- 66.719F MN=4.3 0103558 28061951 00.2430.288 0.4  3  8  41.20 218.00   0 1ML=5.0  20  0 3.62
$ 50.000   -67.500  MN=4.2  CEEF AND SMITH LOCATION
$   SMITH'S ASSESSED ACCURACY: +/-10'N +/-12'W
$ COMPUTATIONS AGREE WITH SMITH WHO COMPUTED 900 KM FOR DISTANCE FROM WES
$ J. EBEL REREAD WES ON 21 NOV 1988:                                                    #51a
$   THE PN AT 0551 FROM BULLETIN IS DUBIOUS; P AT 0602 OR 0604;
$   SN AT 0720 (NS) OR 0704 (EW); LG AT 0818, NOT CLEARLY DEFINED
$ DUE TO POOR QUALITY, WES PHASES NOT USED, BUT ARE CONSISTENT WITH EPICENTRE
$ AN ALTERNATE EPICENTRE BEFORE WES LG WAS CONFIRMED WAS NEAR NEWCASTLE, N.B.
$ BURKE SAYS NO FELT EARTHQUAKE REPORTED IN NEWCASTLE NEWSPAPERS THAT WEEK
$ THEREFORE LOWER ST LAWRENCE LOCATION IS RETAINED
$
SFA  5106280103P  B0452          XC0459      B0535   B0552   080 1.9 025
SFA   SW 0420KM 10 -079 228 49    00 -466     10  021 10 -002   0010334 49ML45MN
SHF  5106280103P XC0518                       B0609   B0633   100 1.6 017
SHF   SW 0572KM 00  670 234 49                10  192 10 -096   0006676 51ML45MN
OTT  5106280103P  B0542                       B0704   B0744   060 117 070
OTT   SW 0831KM 10 -085 238 49                10  187 10 -139   0000627 46ML37MN
WES  5106280103P XC0551          XB0603      XC0710  XC0818   100 032 120
WES   SW 0891KM 00  083 205 49    00 -999$    00  510 00 1602$  0002356 53ML44MN
               Z


+49.268- 66.002F MN=3.9 0819351 19091951 00.1370.172 0.3  4 11  41.92 218.00   0 1ML=4.9  10  0 3.62
$  49.300   -66.250   MN=4.3  CEEF AND SMITH LOCATION
$   SMITH'S ASSESSED ACCURACY: +\-20'N +/-25'W
$ CARD DIFFICULT TO READ
$ SFA - INSTRUMENT UNKNOWN, SUSPECT SPZ BENIOFF, K ABOUT 18                             #51b
$
SFA  5109190819P  B2034           B2043      B21165  B2134   070      215
SFA   SW 0431KM 10  057 238 49     10 -172    10  011 10 -029   0000000 00ML00MN
SHF  5109190819P                  XB2103     B2149   B2218   100 1.6 010
SHF   SW 0589KM          242-88    00 -719    10 -098 10  009   0003927 49ML43MN
OTT  5109190819P  B2126                      B2249   B2329   060 068 030
OTT   SW 0851KM 10  136 243 49                10  327 10 -127   0000462 45ML36MN
WES  5109190819P XB2140                                        060 120 055
WES   SW 0870KM 00 1308$210 49                                   0000480 46ML37MN
KLC  5109190819P                              B2322   B2425   100 009 017
KLC   W  1039KM          268 49               10 -384 10  272   0001187 52ML42MN
               Z


+49.538- 65.811F MN=4.7 0958304 24011953 00.0520.051 0.4  5 14  61.10 218.00   0 1ML=5.1  20  0 3.62
$ CEEF EPICENTRE: 49.07N 66.0W  MN = 4.6
$   SMITH'S ASSESSED ACCURACY: +/-15'N +/-15'W
$ FELT ON THE GASPE PENNINSULA
$ SEISMOGRAMS MISSING FROM LAPERRIERE WAREHOUSE                                         #53a


$
SFA  5301240959P   59325           X5942       60175   6036   040  21 500
SFA   SW 0459KM 10  037 236 49     00 -251    10 -013 10 -131   0037400 55ML51MN
HAL  5301240959P   5946                        6039    6109   100  23 100
HAL   S  0571KM 10  027 162 49                10 -236 10  087   0002732 47ML41MN
SHF  5301240959P   59526                       6052    6121   050  14 210
SHF   SW 0616KM 10  137 240 49                10  103 10  040   0018850 57ML50MN
OTT  5301240959P   6024                        6148    X6229   040  85 230
OTT   SW 0877KM 10  089 242 49                10  142 00 -378   0004250 54ML46MN
WES  5301240959P                                               060 100 195
WES   SW 0903KM          210 49                                  0002042 52ML43MN
KLC  5301240959P   6044                        6223    6321   050  10  45
KLC   W  1054KM 10 -075 267 49                10 -134 10 -074   0005655 58ML49MN
RES  5301240959P                              X7305
RES   N  3117KM          344 33               00 1349$  0000000 00ML00MN
               Z


+49.603- 65.137F MN=4.3 2252518 14091953 00.0600.067 0.2  6 17  61.57 218.00   0 1ML=4.9  20  0 3.62
$ CEEF EPICENTRE: 49.1N -65.2W  MN 4.4
$  SMITH'S ASSESSED ACCURACY: +\-0.5 DEG N +/-0.5 DEG W
$ SFA - ADDITIONAL TIME CORRECTION OF -9 SEC; SEE TEXT FOR FURTHER DISCUSSION
$ CHANGING ARBITRARY TIME CORRECTION ON SFA BY 2 SEC MOVES EPICENTRE 5 KM ALONG NNE-SSW AXIS
$ HAL LP BENIOFF: MAX. 0.7 MM (ZERO TO PEAK) @ 1.0 SEC WITH 2.3K GAIN GIVES MN=3.9, ML=4.5   #53b
$ WES TIMES READ FROM PHOTOCOPIES OF ORIGINAL SEISMOGRAMS SENT FROM WESTON OBSERVATORY
$ KLC PHASES WEAK
$
SFA  5309142254P   54085    -9.0                54570   55215  070  21 200
SFA   SW 0504KM 10  045 239 49                10 -065 10  133   0008549 51ML45MN
HAL  5309142254P   5408                        5500    5529   050  50 135
HAL   S  0565KM 10  155 167 49                10 -155 10  105   0003393 47ML42MN
SHF  5309142254P                  5436        55207   5554   100  16 100
SHF   SW 0662KM          242-88    10 -267    10 -152 10 -078   0003927 51ML44MN
OTT  5309142254P   54515                       56205   5708   050  84  90
OTT   SW 0924KM 10  126 244 49                10  256 10  090   0001346 50ML42MN
WES  5309142254P   54499                       56179   57114  050 120 100
WES   SW 0934KM 10 -163 213 49                10 -230 10  137   0001047 49ML41MN
KLC  5309142254P   55140                       5655    X5750  080  10  25
KLC   W  1103KM 10  183 267 49                10 -121 00 -673   0001963 55ML44MN
               Z


+48.985- 67.428O MN=3.1 2104223 10011954 00.2180.195 0.0  2  4  10.45 218.00   0 1ML=0.0  00  0 3.62
$ 49.170   -68.230  MN=3.1   CEEF AND SMITH LOCATION
$  SMITH'S ASSESSED ACCURACY: +/-15'N +/-19'W
$ ALTERNATE SOLUTION
$+47.551- 66.543O MN=3.1 2104223 10011954 00.2320.148 0.0 2  4  10.45 218.00   0 1ML=0.0  00  0 3.62   #54a
$ THE MORE NORTHERN SOLUTION WAS ADOPTED (IN AGREEMENT WITH SMITH'S ANALYSIS)
        BECAUSE NO PHASE WAS SEEN ON THE WESTON RECORDS
$ HAL - HALIFAX RECORD BLANK THIS DAY
$ SHF - ORIGINAL WOOD ANDERSON RECORD READ AND NO TRACE SEEN (TIME CORRECTION ASSUMED)
$ WES - WESTON SHOWED NO PHASE ACCORDING TO EBEL
$
SFA  5401102104P  C0511           B0515              B0553   060 000 025
SFA   SW 0327KM 03  298 232 49    11 -025            11  006   0000000 00ML00MN
SCH  5401102104P
SCH   N  0651KM          004 49                                  0000000 00ML00MN
OTT  5401102104P                                    B0748   080 051 010
OTT   SW 0744KM          241 49                     11  000   0000154 39ML31MN
               Z
```

```
+48.856- 68.333O MN=3.6 0129566 08091954 00.1110.066 0.1  5  9  31.55 218.00   0 1ML=3.6  10  0 3.62
$ MOUNTED IN SCRAP BOOK
$   49.030   -68.370   MN=3.6  CEEF LOCATION
$   49.03    -68.37    ML=4.3  SMITH LOCATION
$        SMITH'S ASSESSED ACCURACY: +/-15'N +/-17'W                                          #54b
$   SFA - SPZ BENIOFF WITHOUT TIME MARKS TIMES BY COMPARISON WITH WOOD-ANDERSON
$       - BENIOFF AMPLITUDE 3.6 MM @ 0.4 SEC, K UNKNOWN
$   HAL - SIGNAL VERY WEAK
$   KLC - GOOD LG
$   OTT - NO PN TO BE READ
$
SFA  5409080129P  B30330          B30375     B31035  B31115  060 2.1 005
SFA   SW 0268KM 10 -206 225 49    10 -248    10  027 10  064   0002493 36ML35MN
SHF  5409080129P                              B3153
SHF   SW 0420KM          234 49               10  024   0000000 00ML00MN
HAL  5409080129P                             B3215   B32395  050 075 005       3
HAL   SE 0593KM          141 49              10  273 10 -095   0000084 32ML26MN
OTT  5409080129P                              B33045  050 082 035
OTT   SW 0680KM          238 49               10  002   0000536 42ML35MN
KLC  5409080129P                              B3358   070 009 006
KLC   W  0868KM          269 49               10  158   0000598 47ML38MN
           Z


+48.875- 66.127O MN=3.4 1251448 03081956 00.1480.093 0.2  6  8  61.29 218.00   0 1ML=3.8  30  0 3.62
$  49.420  -66.170  MN=3.5  CEEF AND SMITH LOCATION.   SMITH'S ASSESSED ACCURACY: +/-12'N +/-18'W
$ FIRST OF 2 SIMILAR EARTHQUAKES ABOUT 30 SEC APART
$ SECOND EARTHQUAKE PEGGED AT LOCATION OF THIS FIRST EARTHQUAKE.AND SFA PN SEEM GOOD BUT SOME UNCERTAINTY ABOUT SFA TIME C
$ HAL, SFA SECOND PHASE FOLLOWS  PN BY 8 SEC - A THIRD EARTHQUAKE?
$ SFA - S PHASES UNCERTAIN
$ HAL PG, SN ; SFA SN, LG MAY BE ASSOCIATED WITH A THIRD EVENT
$ RECORDS MOUNTED IN SCRAPBOOK                                                              #56a
$ A VERY DIFFICULT SUITE OF SEISMOGRAMS TO INTERPRET!
$
SFA  5608031251P                                                  080 1.7 003
SFA   SW 0401KM          243 49                                     0001386 40ML36MN
SFA  5608031251P  A52406     -0.0 XB5249     XB5327  XB5346   070 000 015
SFA   SW 0401KM 18  109 243 49    00 -064     00  722 00 1019$  0000000 00ML00MN
HAL  5608031251P  A5252  D       XB5301     XB53513  B5408    040 072 017
HAL   SE 0510KM 18 -069 157 49    00 -608     00  851 05  231   0000371 36ML32MN
SHF  5608031251P                              B5421   050 025 010
SHF   SW 0561KM          245 49               05  108   0000503 39ML34MN
MNT  5608031251P                              B54524  050 126 023
MNT   SW 0681KM          239 49               05 -053   0000229 39ML32MN
OTT  5608031251P                              B5529   040 086 020
OTT   SW 0824KM          246 49               05 -345   0000365 42ML35MN
KLC  5608031251P                             B5531   B5626   080 008 004
KLC   W  1030KM          271 49              05 -250 05 -334   0000393 47ML37MN
           Z


+48.875- 66.127F MN=3.5 1252156 03081956 00.1410.103 0.3  6 11  70.00H218.00   0 1ML=3.9  30  0 3.62
$  49.420   -66.170   MN=3.6  CEEF AND SMITH LOCATION
$       SMITH'S ASSESSED ACCURACY: +/-12'N +/-18'W
$ PEGGED AT LOCATION OF FIRST EARTHQUAKE, FREE LOCATION WAS:
                                                                                            #56b


$+49.074- 66.207F MN=3.5 1252133 03081956 00.0710.053 0.3  6 11  61.22 218.00   0 1ML=3.9  30  0 3.6
$  SECOND AND LARGER OF TWO EVENTS ABOUT 30 SEC APART
$  SFA -  BENIOFF NOT CALIBRATED
$  HAL -  LG IN TAIL OF EARLIER EVENT
$
SFA  5608031252P                                                  060 2.1 004
SFA   SW 0401KM          243 49                                     0001995 41ML37MN
SFA  5608031252P  B5310          B5319              B5407   060      015
SFA   SW 0401KM 10 -031 243 49    10 -144            10  037   0000000 00ML00MN
HAL  5608031252P  B53225 D       XB53315     B54168 XB54525  040 097 026
HAL   SE 0510KM 10 -099 157 49    00 -638     10  321 00 1600$  0000421 36ML32MN
SHF  5608031252P  C5331                             B5451   090 028 013
SHF   SW 0561KM 03  122 245 49                      10  027   0000324 38ML32MN
MNT  5608031252P                                    B5523   060 105 042
MNT   SW 0681KM          239 49                     10 -074   0000419 42ML34MN
OTT  5608031252P                                    B55595  050 088 036
OTT   SW 0824KM          246 49                     10 -376   0000514 45ML37MN
WES  5608031252P                                                  050 090 035
WES   SW 0827KM          211 49                                     0000489 44ML36MN
KLC  5608031252P                                   B5601   B5656   080 009 006
KLC   W  1030KM          271 49                    10 -331 10 -415   0000524 49ML38MN
           Z


+48.814- 69.714O MN=3.4 1440052 27101956 00.0880.051 0.4  5  9  31.12 218.00   0 1ML=3.7  30  0 3.62
$  48.250   -69.000   ML=3.4  CEEF AND SMITH LOCATION
$    SMITH'S ASSESSED ACCURACY: +\-20'N +/-25'W
$ EARTHQUAKES PROBABLY OCCURRED IN SAME PLACE, EVEN THOUGH EPICENTRES DIFFER.
$ ORIGINAL RECORDS CUT OUT AND PASTED IN SCRAPBOOK - PHASES REREAD                           #56c
$ FIRST OF TWO EVENTS 23 MINUTES APART
$ HAL - PHASES ADDED FROM ORIGINAL RECORD
$ SFA - TC GIVEN AS  -49 MIN 19.1 SEC
$ SFA - TC UNCERTAIN, ARBITARY TIME CORRECTION ASSUMED
$ SFA - BENOIFF SPZ SENSITIVITY UNKNOWN
$ SAME STATIONS READ AS FOR FOLLOWING EVENT
$
SFA  5610271440P  B4002     +34.  B4004              B4027   040 000 010
SFA   SW 0206KM 11 -008 204 49    11 -058            11 -131   0000000 00ML00MN
SHF  5610271440P                  B41000             B41415  050 025 060
SHF   SW 0340KM          223-87   11 -024            11  209   0003016 40ML38MN
MNT  5610271440P                                    B4216   040 126 019
MNT   SW 0473KM          220 49                     11  001   0000237 33ML29MN
OTT  5610271440P                                  XC42115  C42435  030 056 015
OTT   SW 0594KM          232 49                    00 -958 03 -581   0000561 38ML35MN
HAL  5610271440P                                   C4234   B4308
HAL   SE 0659KM          133 49                    03 -106 11  055   0000000 00ML00MN
           Z
```

```
+48.814- 69.714O MN=3.0 1503519 27101956 00.3660.313 0.3   5 10   30.00H218.00    0 1ML=3.4   30   0 3.62
$   48.250   -69.000   ML=3.4   CEEF AND SMITH LOCATION
$    SMITH'S ASSESSED ACCURACY: +/-20'N +/-25'W
$ PEGGED AT LOCATION OF FIRST EARTHQUAKE, FREE LOCATION WAS:
$+48.939- 69.569O MN=3.0 1503499 27101956 00.1140.101 0.3   5 10   30.81 218.00    0 1ML=3.2   20   0 3.6
$ PRECEEDED 23 MIN EARLIER BY ANOTHER EARTHQUAKE                                                        #56d
$ EARTHQUAKES PROBABLY OCCURRED IN SAME PLACE, EVEN THOUGH EPICENTRES DIFFER.
$ RECORDS IN SCRAPBOOK - PHASES REREAD
$ HAL - PHASES ADDED FROM ORIGINAL RECORD
$ SFA - ARBITRARY TIME CORRECTION ASSUMED
$ SFA - BENIOFF SPZ SENSITIVITY UNKNOWN
$ SAME STATIONS READ AS FIRST EVENT
$
SFA  5610271503P    03532     +31.    03562       04157    04197   050 000 010
SFA    SW 0206KM 07   144 204 49     07  194      07  143 07  171    0000000 00ML00MN
SHF  5610271503P                    B0445                A05290   070 027 010
SHF    SW 0340KM           223-87    07 -192              27  291    0000332 32ML28MN
MNT  5610271503P                                         C0602    040 118 015
MNT    SW 0473KM           220 49                        02 -067    0000200 32ML28MN
OTT  5610271503P                                         C0634    040 063 015
OTT    SW 0594KM           232 49                        02 -198    0000374 37ML33MN
HAL  5610271503P                                  C0619    C0652
HAL    SE 0659KM           133 49                 02 -274 02 -213    0000000 00ML00MN
             Z


+50.383- 65.380F MN=4.0 1913313 16101957 00.0670.066 0.3   6 16   61.37 218.00    0 1ML=4.1   10   0 3.62
$  50.500   -64.870   MN=4.1  CEEF AND SMITH LOCATION
$    SMITH'S ASSESSED ACCURACY: +/-19'N +/-19'W
$ SFA - PHASE AT 1449 NOT USED
$ MANY IMPULSIVE ABRRIVALS READ TO NEAREST 1/10 SECOND BY SMITH
$ DIDN'T REREAD HALIFAX RECORD                                                                          #57
$
SFA  5710161913P  B14415 C          B14570     B15361  B1601    070 117 100
SFA    SW 0540KM 10 -151 230 49      10 -159     10  019 10  026    0000767 41ML35MN
HAL  5710161913P  B1459           XB1520    XB1555    B1631    080 031 080
HAL    S   0653KM 10  225 167 49    00  322     00 -489 10 -089    0002027 49ML41MN
SHF  5710161913P  B15012                       B16097  B16407   060 002 007
SHF    SW 0693KM 10 -035 235 49                10  144 10 -206    0003665 51ML44MN
MNT  5710161913P  B15165 D                     B16340  B17195   080 078 075
MNT    SW 0821KM 10 -067 232 49                10 -151 10  139    0000755 47ML38MN
OTT  5710161913P  B1533                        B1706   B1754    040 063 075
OTT    SW 0951KM 10 -005 238 49                10  279 10 -008    0001870 51ML43MN
WES  5710161913P                               B1714            050 118 045
WES    SW 1000KM           209 49              10  042            0000479 47ML38MN
PAL  5710161913P                                      XB1906
PAL    SW 1235KM           216 49                     00 -659    0000000 00ML00MN
             Z


+49.093- 67.985O MN=3.5 0932556 21101958 00.1630.177 0.1   5 11   21.75 218.00    0 1ML=4.0   10   0 3.62
$ 49.600   -68.000   ML=4.1   CEEF AND SMITH LOCATION
$   SMITH'S ASSESSED ACCURACY: +/-0.5 DEG N +/-0.5 DEG W
$ HAL - VERY WEAK ON HALIFAX WILMORE
$                                                                                                       #58
SFA  5810210932P                                      A34207
SFA    SW 0305KM           225 49                     14  074    0000000 00ML00MN


SHF  5810210932P                               B3447   A34592   050  16 015
SHF    SW 0456KM           233 49              04  480 14 -252    0001178 40ML36MN
MNT  5810210932P  A34117          A34298       A35115  B3539
MNT    SW 0584KM 14 -088 229 49    14 -010     14  204 04  191    0000000 00ML00MN
HAL  5810210932P                               B3538
HAL    SE 0598KM           144 49              04 -291    0000000 00ML00MN
OTT  5810210932P  B3431                        B3543   B3613    030 146 025
OTT    SW 0715KM 04   243 238 49               04  565 04 -029    0000359 39ML34MN
             Z


+48.452- 68.342F MN=3.5 1352510 01081959 00.0620.031 0.2   5 11   50.84 218.00    0 1ML=4.0   30   0 3.62
$ CEEF EPICENTRE: 48.42N 68.32W  ML = 4.1
$   SMITH'S ASSESSED ACCURACY: +/-12'N +/-12'W
$ SFA UNCALIBRATED: NO MAGNITUDE DATA
$ ORIGINAL RECORDS NOT SEEN
$                                                                                                       #59a
SFA  5908011352P    53260                       53515    53575
SFA    SW 0238KM 10   019 232 49               10  027 10  053    0000000 00ML00MN
SHF  5908011352P    53465                        5441    090  28  42
SHF    SW 0395KM 10   158 239 49                10  079    0001047 39ML34MN
MNT  5908011352P    53593                        5451    5514    040 110  75
MNT    SW 0519KM 10 -076 233 49                 10  001 10 -048    0001071 40ML36MN
HAL  5908011352P    5404                         5526    050  25  14
HAL    SE 0559KM 10 -098 138 49                 10  037    0000704 40ML35MN
OTT  5908011352P                                 5551    040  85  40
OTT    SW 0657KM           242 49                10 -152    0000739 43ML36MN
WES  5908011352P                                           050 118 025
WES    S   0714KM           200 49                          0000266 40ML33MN
             Z


+49.894- 67.127O MN=3.3 0136254 25091959 00.1610.185 0.1   4   8   50.50 218.00    0 1ML=3.8   20   0 3.62
$  50.180   -68.200   ML=3.9    CEEF AND SMITH LOCATION
$        SMITH'S ASSESSED ACCURACY: +\-35'N +/-35'W
$ MOVED EAST TO LIE UNDER ST. LAWRENCE RIVER
$ HAL - NOTHING ON ORIGINAL HAL RECORD - A WILLMORE SPZ 30 MM/MIN
$ MNT - SMITH'S EMERGENT PHASE AT 01:38:55 DOESN'T FIT                                                  #59b
$
SFA  5909250136P                               A38026  B3817    040 037 016
SFA    SW 0412KM           223 49              16 -013 04 -244    0000679 36ML33MN
SHF  5909250136P                               B38345  B38585   070 027 015
SHF    SW 0560KM           231 49              04  032 04 -179    0000499 40ML34MN
MNT  5909250136P                               A3902   A39365   060 105 026
MNT    SW 0690KM           227 49              16  016 16  032    0000259 40ML32MN
OTT  5909250136P                               B3928   B4010    040 086 020
OTT    SW 0816KM           235 49              04 -071 04 -105    0000365 42ML35MN
WES  5909250136P                                           050 118 015
WES    SW 0896KM           203 49                          0000160 41ML32MN
             Z
```

```
+50.081- 66.781F MN=4.2 2243458 05071961 00.0380.032 0.4  5 12  40.72 218.00   0 1ML=5.1  10  0 3.62
$ CEEF EPICENTRE: 50.25N 66.68W  MN = 4.3
$ FELT AT THE RAILWAY TO TIKA (MILE 57) BUT NOT BEYOND.
$ NOT FELT AT MATANE ON THE SOUTH SHORE OF THE RIVER.
$ FELT REPORTS AVALIABLE (SEE APPENDIX G)
$ BCIS SEISMIC BULLETIN GIVES TIMES FOR WES, MRG, RES, AND TWO OTHER DISTANT US STATIONS                #61
$ RES LG AT 5752 DOES NOT FIT, DISTANCE FROM EPICENTRE TO RES IS 3000 KM
$ MRG PN AT 5023 DOES NOT FIT
$ SCH RECORD NOT AVAILABLE
$
SHF  6107052245P   45040                      46006   46291  040  24 120
SHF   SW 0592KM 10  018 231 49                10 -084 10 -050   0007854 51ML46MN
HAL  6107052245P   45110                      46143   4645   050  38  27
HAL   SE 0652KM 10 -003 157 49                10  027 10 -094   0000893 44ML37MN
MNT  6107052245P   45196                      46285  X4702   040  75 200
MNT   SW 0722KM 10 -007 228 49                10 -060 00 -349   0004189 51ML45MN
OTT  6107052245P   4536                       46562   4740   060  77  80
OTT   SW 0849KM 10  094 236 49                10  026 10 -034   0001088 49ML40MN
WES  6107052245P  X4554                                 4803
WES   SW 0925KM 00  968 204 49                         10  169   0000000 00ML00MN
MRG  6107052245P                                       X5108
MRG   SW 1556KM          227 49                        00 1232$  0000000 00ML00MN
           Z


+46.818- 70.695O MN=3.2 1300292 15121962 00.1550.230 0.3  3  4  30.91 218.00   0 1ML=3.0  20  0 3.62
$ THE TOWN MANAGER OF SEPT-ILES CALLLED FATHER BUIST TO SAY THE SHOCK WAS FELT AND "SIDEWALKS CRACKE
$ LOCATED BY SMITH AT COORDINATES OF SEPT-ILES PQ (BASED ON  FELT REPORT AND MNT RECORD)
$ MNT -  HOUR MARKS MISLABELED THEREFORE SMITH THOUGHT THIS EVENT OCCURRED AT 01 HOURS
$        BECAUSE OF MISLABELED TIMES ON MNT, SMITH MISSED TRACES ON SCH AND SHF                       #62
$ SHF -  RECORD LABELED "MELOCHVILLE BLAST"; MELOCHVILLE IS 30 KM SOUTH-WEST OF MONTREAL
$ SFA -  NOT OPERATING FOR 3 MONTHS (STEVENS, BSSA, 1980)
$ MNT -  POOR P AND S PHASES
$ SCH -  EXCELLENT LG BUT ONLY FITS IF 1 MINUTE ERROR IN TIMING, OTHER PHASES DUBIOUS.
$ HAL -  NOT VISIBLE AT ALL ON ORIGINAL RECORDS (SPZ WILLMORE)
$ LOCATES NEAR ST-RAPHAEL  ABOUT 30 KM EAST OF QUEBEC CITY
$ CEEF LOCATION  50.200 -68.380  MN =4.0  (AT SEPT-ILES)
$ NOW CONFIRMED AS A MUCH SMALLER EVENT NEAR QUEBEC CITY; STILL MIGHT BE A LOCAL BLAST
$ IF A BLAST AT 0 KM DEPTH, EPICENTRE MOVES 7 KM TO THE SOUTHEAST,  46.765  -70.622
$ PIERRE GOUIN CHECKED QUEBEC CITY FOR FELT EARTHQUAKE REPORTS BUT FOUND NO MENTION
$
SHF  6212151300P  A00542                                 A01140  050 016 018
SHF   W  0161KM 11 -045 260 49                            11 -008   0001414 28ML29MN
MNT  6212151300P XB0111          XB0113                   B0150   040 110 090
MNT   SW 0270KM 00  312 238 49    00  014                 03  609   0001285 32ML32MN
SCH  6212151300P                                          A0447   030 188  25
SCH   N  0932KM          016 49                           11  016   0000279 42ML35MN
           Z


+49.947- 65.145O MN=2.8 0629316 19101963 00.0590.090 0.1  2  4  20.41 218.00   0 1ML=2.9  20  0 3.62
$ ALTERNATE LOCATION FOLLOWS:
$50.046- 68.234O MN=2.8 0629333 19101963 00.0160.026 0.2  2  4  20.11 218.00   0 1ML=2.8  20  0 3.62
$ THIS LOCATION THOUGHT LESS LIKELY
$  50.00   -67.80 ML=2.9  CEEF LOCATION                                                               #63
$  50.00   -65.0  OR ALTERNATIVELY  50.00   -67.80  ML = 2.9   SMITH LOCATIONS
$ HAL - RECORD EXAMINED, BUT NO TRACE SEEN




$ SFA - RECORD EXAMINED, AGAIN NO TRACE SEEN
$
SIC  6310190629P                  B29512              B3004   040 140 130
SIC   W  0117KM          283-81   10  050             10 -029   0001459 25ML27MN
MNQ  6310190629P
MNQ   W  0267KM          286 49                                 0000000 00ML00MN
SCH  6310190629P                  B31005              B3205   030 188 015
SCH   N  0554KM          349-88   10 -050             10  029   0000167 32ML29MN
           Z


+49.448- 67.958O MN=2.2 0913003 07041964 00.0370.061 0.0  3  4  20.15 218.00   0 1ML=1.9  10  0 3.62
$ 49.420 -67.910  ML=2.0  CEEF LOCATION
$
SIC  6404070913P                   13200               13335  030 160 038
SIC   NE 0119KM          047-81   11  021             11 -016   0000497 19ML22MN
SFA  6404070913P                                       14330                                          #64a
SFA   SW 0335KM          221 49                        11 -004   0000000 00ML00MN
SCH  6404070913P                                       C1547   040 098 002
SCH   N  0603KM          007 49                        03 -012   0000032 28ML22MN
           Z


+49.361- 67.138F MN=3.5 2141307 01071964 00.0340.097 0.2  6 13  51.28 218.00   0 1ML=3.4  10  0 3.62
$ CEEF EPICENTRE: 49.43N 67.42W   ML = 3.8
$ BCIS EPICENTRE: 49.4N  70.0W    ("BY INSPECTION", FROM US DATA ONLY)
$ CBM, MIM, EMM, BNH, PHASES FROM BCIS
$ NO MAGNITUDE DATA FOR SIC OR US STATIONS                                                             #64b
$ US STATIONS EMM, MIM, AND BNH HAVE VERY LARGE RESIDUALS
$
SIC  6407012141P                   41460               41580
SIC   N  0095KM          018-79   10 -032             10  059   0000000 00ML00MN
CBM  6407012141P                   42152               4250
CBM   S  0280KM          196-86   10 -081             10  173   0000000 00ML00MN
SFA  6407012141P   42190                    43000   43120  040 109  50
SFA   SW 0370KM 10 -264 229 49                10  090 10 -117   0000721 34ML32MN
MIM  6407012141P                  X42429   X4327
MIM   S  0480KM          198-88   00 -536   00  455             0000000 00ML00MN
EMM  6407012141P  X42445                                 X4405
EMM   S  0515KM 00  525 183 49                         00 1192$  0000000 00ML00MN
SCH  6407012141P                                        43515   44180  040  94  33
SCH   N  0608KM          002 49                        10  172 10 -086   0000551 41ML35MN
BNH  6407012141P  X42581                               X4359
BNH   SW 0616KM 00  645 212 49                         00  754           0000000 00ML00MN
MNT  6407012141P   42550                               43580   44320  040 125  35
MNT   SW 0651KM 10 -082 231 49                         10 -074 10  142   0000440 40ML34MN
OTT  6407012141P                                       44280  X45040  040  57  15
OTT   SW 0784KM          239 49                        10  101 00 -325   0000413 42ML35MN
WES  6407012141P                                                 050 074 030
WES   SW 0841KM          204 49                                  0000509 45ML37MN
           Z
```

```
+50.406- 65.010O MN=3.1 0935306 12081964 00.0390.042 0.4  3  7  20.72 218.00   0 1ML=3.7  10  0 3.62
$ 50.470  -64.870  ML=3.7  CEEF LOCATION
$ LOCATION SIMILAR TO THE CEEF LOCATION (WHICH FOLLOWS SMITH)
$ ADDITION OF NEW STATIONS ELIMINATED THE ALTERNATE SOLUTION SMITH HAD REJECTED
$                                                                                          #64c
SIC  6408120935P                    A35510                  36075
SIC   W  0126KM          259-82     23 -018                 06  169   0000000 00ML00MN
SCH  6408120935P  B36389            XB3649      B37286      B37496  040 098 035
SCH   N  0506KM 06  081 347 49      00 -329     06  071 06 -089   0000561 37ML33MN
HAL  6408120935P                                        XC38391
HAL   S  0651KM          170 49                         00  867   0000000 00ML00MN
STJ  6408120935P                                    39046   39521  040 102 004
STJ   E  0952KM          105 49                     06  196 06 -147   0000062 36ML28MN
           Z


+49.572- 66.012O MN=2.6 1204262 18031965 00.0810.323 0.0  3  6  20.00N218.00   0 1ML=3.0  20  0 3.62
$ +49.770  -67.530  ML = 2.8 CEEF LOCATION
$ ORIGINAL DATA NOT FOUND SO SEISMOGRAMS REREAD
$ FIRST OF TWO EVENTS APPROXIMATELY 5 MINUTES APART
$ SIC - S APPROXIMATE, SAME S-P AS SECOND EVENT
$ PEGGED AT SECOND EVENT LOCATION                                                          #65a
$ SCH - POOR PHASES, ESPECIALLY WHEN COMPARED TO 2ND EVENT
$
SIC  6503181204P                    A04403 D                B04485
SIC   NW 0085KM          322-78     21  011                 05 -166   0000000 00ML00MN
SFA  6503181204P                    B0535       B0611       B0629   040 133 011
SFA   SW 0449KM          234-88     05 -369     05 -030 05 -135   0000130 30ML26MN
SCH  6503181204P                                XC0635      B0707   030 188 008
SCH   N  0587KM          355 49                 00 -563 05 -135   0000089 30ML26MN
           Z


+49.572- 66.012F MN=3.0 1209013 18031965 00.0450.095 0.1  4  9  20.82 218.00   0 1ML=3.4  20  0 3.62
$ +49.770  -67.530  ML = 3.1   CEEF LOCATION
$ ORIGINAL DATA NOT FOUND SO SEISMOGRAMS REREAD
$ SECOND AND LARGER OF TWO EVENTS APPROXIMATELY 5 MINUTES APART
$ SIC - GIVES GOOD P, APPROXIMATE S
$ SCH - GOOD ONSETS                                                                        #65b
$ SFA - PN NOT SEEN
$ HAL - POOR PHASES
$
SIC  6503181209P                    A09156 D                B0924
SIC   NW 0085KM          322-78     19  030                 05 -127   0000000 00ML00MN
SFA  6503181209P                    B10115      B1049       B1104   030 167 035
SFA   SW 0449KM          234-88     05 -230     05  258 05 -147   0000439 34ML31MN
HAL  6503181209P                                C1122               030 167 002      3
HAL   S  0579KM          161 49                 01  801             0000025 24ML21MN
SCH  6503181209P  A10184                        B11174      B11424  040 157 018
SCH   N  0587KM 19 -021 355 49                 05  166 05 -106   0000180 34ML30MN
           Z


+49.590- 66.937F MN=3.9 1436503 05101965 00.0210.048 0.3  6 11  51.02 218.00   0 1ML=4.5  10  0 3.62
$ CEEF EPICENTRE: 49.78N 67.66W   MN = 3.9
$ EVENT NOT LISTED IN BCIS

                                                                                           #65c


$ SCH, OTT, HAL, STJ  TIMES RE-READ
$ STJ PN PHASE VERY POOR
$ HAL LG ATTENUATED 2 MM PEAK TO PEAK ONLY; NOT USED FOR MAGNITUDE
$ HAL SN 4 MM ZERO TO PEAK AT 0.3 SEC AT 135 K GIVES ML=4.0; MN=3.5
$ SIC RECORD NOT FOUND
$
SIC  6510051436P                    37027
SIC   N  0066KM          012-75     10  122                                 0000000 00ML00MN
SCH  6510051436P   38052                            39045   39320  030 100 130
SCH   N  0582KM 10 -196 001 49                      10  060 10  066   0002723 45ML41MN
HAL  6510051436P   38095                            39080   3939
HAL   SE 0607KM 10 -055 154 49                      10 -095 10  100   0000000 00ML00MN
OTT  6510051436P                                    39530   X40310  040  57  41
OTT   SW 0809KM          238 49                     10  091 00 -298   0001130 47ML40MN
WES  6510051436P                                                    050 074 020
WES   SW 0870KM          205 49                                     0000340 44ML35MN
GWC  6510051436P   38550                            40250   X41150  050  86  75
GWC   NW 0970KM 10  058 315 49                      10 -136 00 -349   0001096 50ML41MN
STJ  6510051436P  X39097                           40476   X41420  050  48  13
STJ   E  1071KM 00  302 097 49                      10 -016 00 -425   0000340 46ML37MN
           Z


+48.918- 67.646F MN=3.9 1529241 14011966 00.0260.054 0.2 11 20  71.22 218.00   0 1ML=4.4  20  0 3.62
$ 48.900  -67.470   MN = 3.9    CEEF LOCATION
$ FIRST OF TWO EVENTS 45 MIN APART.
$                                                                                          #66a
SIC  6601141529P                    A29491 D                X30046
SIC   NE 0154KM          025-83     30 -013                 00 -249   0000000 00ML00MN
CBM  6601141529P   29571
CBM   S  0224KM 08 -008 189 49                                          0000000 00ML00MN
SFA  6601141529P   30084            30124       30409   30489  040 028 130
SFA   SW 0310KM 08  068 231 49      08 -188     08  118 08 -110   0007293 42ML41MN
MIM  6601141529P   30211
MIM   S  0422KM 08 -028 195 49                                          0000000 00ML00MN
EMM  6601141529P   30256
EMM   S  0465KM 08 -098 178 49                                          0000000 00ML00MN
HAL  6601141529P  B30397            X30618      31335               040 060 045      3
HAL   SE 0568KM 08  057 145 49      00  600     08 -101             0001178 42ML37MN
MNT  6601141529P   30425            31395   32045   070 098 215
MNT   SW 0591KM 08  054 232 49      08  005 08 -301   0001969 46ML40MN
SCH  6601141529P   30513            31563   32260   040 094 131
SCH   N  0660KM 08  092 005 49      08  215 08 -050   0002189 47ML41MN
OTT  6601141529P                    32120   32440   050 046 068
OTT   SW 0727KM          240 49     08  371 08 -094   0001858 48ML41MN
WES  6601141529P                    32232           050 118 035
WES   SW 0781KM          203 49     08  337             0000373 42ML35MN
GWC  6601141529P   31293                        X33578  050 086 035
GWC   NW 0990KM 08 -134 320 49                  00  002   0000511 47ML38MN
LND  6601141529P                    X34000      X35030  080 074 043
LND   SW 1234KM          243 49     00  375 00 -206   0000456 50ML39MN
           Z
```

```
+48.860- 67.558O MN=3.2 1614073 14011966 00.0240.045 0.2  7 14  40.95 218.00   0 1ML=3.2  20  0 3.62
$  48.900  -67.500  ML=3.4  CEEF LOCATION
$  SECOND OF TWO EVENTS 45 MIN APART
$
SIC  6601141614P                  A14327 D            14511  030 160 200
SIC   N  0158KM          022-83   28 -027             07 -012   0002618 29ML32MN
SFA  6601141614P  14519            14584    15249    15324
SFA   SW 0311KM 07  085 233 49    07  074  07  175 07 -110   0000000 00ML00MN
HAL  6601141614P                              16165
HAL   SE 0559KM          146 49               07  070          0000000 00ML00MN
MNT  6601141614P                              16245   16485  040 125 021
MNT   SW 0592KM          233 49               07  159 07 -254   0000264 36ML31MN
SCH  6601141614P                              16395   17125  030 031
SCH   N  0666KM          004 49               07  088 07  116   0000000 00ML00MN
OTT  6601141614P                                      17280  050 046 015
OTT   SW 0729KM          241 49                      07 -082   0000410 42ML35MN
WES  6601141614P                                             050 118 010
WES   SW 0777KM          204 49                               0000106 37ML29MN
GWC  6601141614P                              17519   18423
GWC   NW 0999KM          320 49               07  237 07 -120   0000000 00ML00MN
           Z
```

#66b

```
+49.590- 66.211F MN=3.1 0106380 12071966 00.0180.099 0.2  9 16  31.16 218.00   0 1ML=3.4  20  0 3.62
$  49.500 -66.000 ML=3.3   CEEF LOCATION
$  HAL - ORIGINAL RECORDS READ AND PHASES ADDED
$  SIC - PHASES REREAD
$
SIC  6607120106P                  A06502              07007
SIC   NW 0075KM          330-77   30 -028             08  134   0000000 00ML00MN
CBM  6607120106P                                      08085
CBM   SW 0328KM          206 49                       08 -028   0000000 00ML00MN
SFA  6607120106P                                      08380  030 069 010
SFA   SW 0439KM          233 49                       08 -131   0000304 32ML30MN
MIM  6607120106P   07480                 08410   09050
MIM   SW 0529KM 08 -021 205 49           08  097 08  087   0000000 00ML00MN
EMM  6607120106P                         08421   09096
EMM   S  0548KM          191 49          08 -211 08  002   0000000 00ML00MN
SCH  6607120106P                         08555   09185  030 100 018
SCH   N  0584KM          356 49          08  370 08 -082   0000377 36ML33MN
HAL  6607120106P  C0753                  C0853   C0919
HAL   S  0586KM 02 -216 159 49           02  084 02 -089   0000000 00ML00MN
BNH  6607120106P                                      09480
BNH   SW 0675KM          216 49                       08  339   0000000 00ML00MN
MNT  6607120106P                                      09560  030 105 009
MNT   SW 0720KM          234 49                       08 -087   0000180 36ML31MN
           Z
```

#66c

```
+49.574- 68.462F MN=3.3 0732195 17071966 00.0280.042 0.2  6 13  60.71 2 2.00   0 1ML=3.4  40  0 3.62
$49.58 - 68.42   ML=3.6
$ MANIC-2 INDUCED EQRTHQUAKE
$  FIRST EVENT OF SEQUENCE; HAPPENED ABOUT 1 YEAR AFTER FILLING RESERVOIR
$ SIC ANALOG NOT AVAILABLE
$ SIC S-P = 16.5 SECONDS
$ SFA PN, SN VERY POOR
```

#66d

```
$
SIC  6607170732P                  A32419              A32585  020 162 150
SIC   NE 0141KM          061-89   19 -040             19  002   0002909 27ML31MN
SFA  6607170732P  B33044          C3312    B33400     A33493  030 030 012
SFA   SW 0324KM 05 -214 214 49    01  012  05 -094 19  016   0000838 32ML32MN
SCH  6607170732P  B33402                   B34402     B35067  030 100 030
SCH   N  0595KM 05  057 010 49             05  153 05  267   0000628 39ML35MN
MNT  6607170732P                                     B35040  050 117 025
MNT   SW 0597KM          223 49                      05 -042   0000269 37ML31MN
HAL  6607170732P                         C34518      B35255
HAL   SE 0662KM          144 49          01 -093 05  310   0000000 00ML00MN
OTT  6607170732P                         X35090      B35370  040 056 015
OTT   SW 0717KM          232 49          00  441 05 -079   0000421 41ML35MN
GWC  6607170732P                         X35410      X36255  050 085 012
GWC   NW 0896KM          319 49          00 -161 00 -167   0000177 41ML33MN
           Z
```

#66e

```
+49.628- 68.396F MN=2.5 1929265 21071966 00.1140.139 0.3  3  8  21.29 2 2.00   0 1ML=2.3  20  0 3.62
$49.50 - 68.33   ML=2.4 CEEF
$ MANIC-2 INDUCED EARTHQUAKE
$ FORESHOCK OF 24 JULY EVENT
$ NOT RECORDED AT HAL, MNT, OTT, WES
$ SFA HALF AMPLITUDE LESS THAN 1 MM
$ SCH S1 COULD BE SEVERAL SECONDS LATER
$ SCH A-PP LESS THAN 1 MM
$ HAL ONSET READ JULY/1987
$
SIC  6607211929P                  A29473              A30040  030 160 090
SIC   NE 0134KM          062-89   19 -078             19  055   0001178 24ML27MN
SFA  6607211929P  B30095          B30220   C3055      B31019  030 069 003
SFA   SW 0332KM 05 -491 214 49    05  195  01  549 05  369   0000091 23ML22MN
SCH  6607211929P  B30465                   B3146      X32150
SCH   N  0588KM 05  078 010 49             05  186 00  593   0000000 00ML00MN
HAL  6607211929P                                     X3227
HAL   SE 0664KM          145 49                      00 -293   0000000 00ML00MN
           Z
```

#66f

```
+49.598- 68.381F MN=3.4 2219482 24071966 00.0160.047 0.2  8 18  61.01 2 2.00   0 1ML=3.5  30  0 3.62
$49.63 - 68.55   ML=3.7  CEEF
$ MANIC-2 INDUCED EARTHQUAKE
$ LARGEST EVENT OF SEQUENCE, CLEARLY NOT AT BAIE COMEAU TOWNSITE
$ HAL TR 030 069 005 GIVES MN=3.0; BELIEVED TO BE ATTENUATED LG
$ SIC ANALOG NOT AVAILABLE TO BE RE-READ
$ CBM S GIVEN AS (S) IN WESTON BULLETIN
$ SFA P1, SN UNCERTAIN
$ SFA GENERALLY BETTER TRAVEL-TIME FOR SURFACE FOCUS
$ MIM DATA FROM WESTON PRELIMINARY BULLETIN AND MICROFILM
$ SCH BETTER FIT FOR ALL JULY EVENTS IGNORING P, AND USING MAINLY S1
$ BNH P GIVEN AS (P) IN WESTON BULLETIN
$ MNT, OTT SN VERY POOR
$
SIC  6607242219P                  A20088              A20255  030 160 260
SIC   NE 0134KM          061-89   16 -108             16  017   0003403 29ML32MN
CBM  6607242219P                  B20345              B21093
CBM   S  0297KM          176-90   04 -164             04 -100   0000000 00ML00MN
SFA  6607242219P  B20345          C2039               X2116   020 028 022
```

```
SFA   SW 0330KM 04 -132 214 49     01 -238            00 -328   0002468 35ML37MN
MIM  6607242219P  B20559                              X22069
MIM   S  0487KM 04  091 186 49                        00  418   0000000 00ML00MN
EMM  6607242219P  B21021                  B21574  B22217
EMM   S  0545KM 04  008 173 49                        04  097 04  303   0000000 00ML00MN
SCH  6607242219P  A21080          B21235  A22070  B22350  040 094 045
SCH   N  0592KM 16  020 010 49     04 -013  16  049 04  336   0000752 40ML36MN
BNH  6607242219P  B21084                  C22100  X22360
BNH   S  0598KM 04 -020 202 49                        01  210 00  254   0000000 00ML00MN
MNT  6607242219P                                      X22310  050 117 038
MNT   SW 0603KM          223 49                       00 -367   0000408 40ML33MN
HAL  6607242219P  A21148                   A22224  X22481
HAL   SE 0661KM 16 -135 145 49                        16  131 00 -257   0000000 00ML00MN
OTT  6607242219P                                      X22364  X23061  040 056 020
OTT   SW 0724KM          233 49                       00  186 00 -204   0000561 42ML36MN
GWC  6607242219P                                      X23522  050 085 015
GWC   NW 0898KM          318 49                       00 -410   0000222 42ML34MN
           Z
```

```
+49.689- 68.404F MN=3.0 1112438 27071966 00.0350.050 0.2  4 10  50.61 2 2.00   0 1ML=3.2  20  0 3.62
$49.42 - 68.42   ML=3.4  CEEF
$ MANIC-2 INDUCED EARTHQUAKE
$ NO SIC ANALOG AVAILABLE
$ NOT RECORDED AT WESTON
$ AFTERSHOCK OF 24 JULY
$ SFA HALF AMPLITUDE LESS THAN 0.5 MM
$ MNT, OTT S1 UNCERTAIN BY SEVERAL SECONDS
$ SCH S1 + OR - SEVERAL SECONDS
$ OTT NOISY TRACE DUE TO TRAFFIC
$                                                                                    #66g
SIC  6607271112P                A13045            A13205  030 160 170
SIC   NE 0131KM          065-89 17 -052           17  040   0002225 27ML30MN
SFA  6607271112P  B13306        B13380  B14070  A14173
SFA   SW 0337KM 04 -179 213 49   04 -025  04 -098 17  028   0000000 00ML00MN
SCH  6607271112P  B14007                  C1459   B15269  030 100 022
SCH   N  0582KM 04 -156 010 49                  01 -108 04  230   0000461 37ML34MN
MNT  6607271112P                                      X15270  050 117 009
MNT   SW 0609KM          222 49                       00 -509   0000097 34ML27MN
HAL  6607271112P                        B15184  X15482
HAL   SE 0670KM          145 49                       04 -031 00 -069   0000000 00ML00MN
OTT  6607271112P                                      X16027  040 056 005
OTT   SW 0729KM          232 49                       00 -245   0000140 36ML30MN
GWC  6607271112P                                      X16457  030 117 005
GWC   NW 0889KM          318 49                       00 -385   0000090 36ML29MN
           Z
```

```
+49.496- 68.3200 MN=2.9 0102385 16081966 00.0530.102 0.2  5 11  41.70 2 2.00   0 1ML=2.6  20  0 3.62
$49.50 - 68.50   ML=3.2  CEEF
$ MANIC-2 INDUCED EARTHQUAKE
$ SFA SN TENTATIVE, ALL AMPLITUDES SMALL
$ MNT S1 ONSET POOR. A-PP = 2MM
$ SCH SN POOR, S1 MAY BE 5 SECONDS EARLIER                                           #66h
$ NOT RECORDED AT HAL OR WES, NORTH OF BAIE COMEAU
$ OTT S1 + OR - SEVERAL SECONDS, A-PP = 1 MM
$
SIC  6608160100P                B02599            B03166  030 160 061
```

```
SIC   NE 0136KM          056-89    11 -071            11  029   0000798 22ML25MN
SFA  6608160100P  B03244                   B03593  B04116  030 030 006
SFA   SW 0323KM 11 -100 216 49                  11 -040 11  377   0000419 29ML29MN
MNT  6608160100P                                      B05220
MNT   SW 0597KM          224 49                       11 -165   0000000 00ML00MN
SCH  6608160100P  C03566         C04127  B04578  B05270  040 094 011
SCH   N  0602KM 03 -286 009 49    03 -300  11 -131 11  210   0000184 36ML30MN
OTT  6608160100P                                      B05569
OTT   SW 0721KM          234 49                       11 -073   0000000 00ML00MN
GWC  6608160100P                                      X0644   040 104 007
GWC   NW 0910KM          319 49                       00 -585   0000106 38ML30MN
           Z
```

```
+49.537- 68.251F MN=3.2 1313348 20081966 00.0530.071 0.3  5 12  31.07 2 2.00   0 1ML=3.3  20  0 3.62
$49.58 - 68.33   ML=3.5  CEEF
$ MANIC-2 INDUCED EARTHQUAKE
$ SIC PHASES DO NOT LINE UP WELL WITH EVENT TIME
$ SIC S-P = 16.5 SECONDS, AMP FADES, A-PP GREATER THAN 20 MM
$ SFA TC UNCERTAIN +2 ON 19TH, +4 ON 21ST, ASSUMED +3.0 SEC                         #66i
$ SFA S1 + OR - SEVERAL SECONDS
$ SCH S1 COULD BE 4 SECONDS EARLIER
$ HAL MK2 NO RECORD
$ HAL ONSET READ JULY/1987
$
SIC  6608201313P                A13549            A14112
SIC   NE 0130KM          056-89 21 -086           21  051   0000000 00ML00MN
SFA  6608201313P  B14252        B14299  B14581  B15081  030 030 006
SFA   SW 0330KM 05  277 216 49   05  191  05  077 05  222   0000419 29ML29MN
SCH  6608201313P  B14545        B15105  B15541  B16223  030 100 019
SCH   N  0597KM 05 -053 009 49    05 -056  05 -010 05  265   0000398 37ML33MN
MNT  6608201313P                                      B16210
MNT   SW 0604KM          224 49                       05 -073   0000000 00ML00MN
HAL  6608201313P                                      X16415
HAL   SE 0650KM          145 49                       00  722   0000000 00ML00MN
OTT  6608201313P                        X16221  B16530  030 067 015
OTT   SW 0727KM          233 49                       00  021 05 -271   0000469 40ML35MN
GWC  6608201313P                                      X1740
GWC   NW 0909KM          318 49                       00 -603   0000000 00ML00MN
           Z
```

```
+49.092- 68.249F MN=3.3 2104123 12121966 00.0250.066 0.2  8 18  21.35 218.00   0 1ML=2.9  10  0 3.62
$ 49.000  -68.170   ML=3.4  CEEF LOCATION
$ HAL - LG ATTENUATED
$                                                                                    #66j
SIC  6612122104P                A04382 D           04576
SIC   NE 0162KM          042-84 30 -054           07  007   0000000 00ML00MN
CBM  6612122104P                 04507             05177
CBM   S  0240KM          178-86 07 -058           07 -130   0000000 00ML00MN
SFA  6612122104P                 04594    05238    05308  020 069 020
SFA   SW 0291KM          222-86 07 -006  07 -011 07 -221   0000911 29ML32MN
MIM  6612122104P   05120                X05582
MIM   S  0432KM 07  119 188 49                  00  430           0000000 00ML00MN
EMM  6612122104P   05178                  06023
EMM   S  0488KM 07  025 173 49                  07 -335           0000000 00ML00MN
BNH  6612122104P   05273                          06460
BNH   SW 0551KM 07  201 206 49                  07  140   0000000 00ML00MN
```

```
HAL  6612122104P  B0534          XC05475     B06325  B07037
HAL   SE 0609KM 07  159 143 49    00 -322    07  092 07  289   0000000 00ML00MN
SCH  6612122104P   05390                      06430   07110  030 100 025
SCH   N  0646KM 07  213 008 49                07  365 07  019   0000524 40ML35MN
            Z


+49.280- 66.068O MN=2.6 0412566 27021967 00.0680.202 0.0  4  5  20.61 218.00   0 1ML=2.6  20  0 3.62
$ 49.170  -66.000  ML=2.3 CEEF LOCATION
$ HAL RECORD REREAD, BUT POOR TRACE
$
SIC  6702270412P                  A13145              13284  030 160 100
SIC   NW 0110KM          334-81   20 -022            05  080   0001309 23ML26MN
SFA  6702270412P                                     14555
SFA   SW 0427KM          238 49                      05  064   0000000 00ML00MN
HAL  6702270412P                                     C1534   030 042 002
HAL   S  0550KM          159 49                      01  541   0000100 30ML26MN
SCH  6702270412P                                     15495
SCH   N  0619KM          356 49                      05  181   0000000 00ML00MN
            Z


+48.651- 64.926F MN=3.4 0808312 05081967 00.0200.071 0.0  6 12  11.03 218.00   0 1ML=0.0  00  0 3.62
$ CEEF EPICENTRE: 48.57N 64.97W  ML = 4.0
$ CARDS GIVE MAGNITUDE DATA FOR SCH ONLY
$ ORIGINAL RECORDS NOT SEEN
$ CENTRAL GASPE PENINSULA
$ EPICENTRE POSSIBLY IN THE LSL - NEEDS HAL AND OTHER CANADIAN STATIONS TO CONFIRM THIS
$
SIC  6708050808P   09030                             09298
SIC   NW 0214KM 10 -017 323 49                      10 -093   0000000 00ML00MN
CBM  6708050808P   09139                             09561
CBM   SW 0306KM 10 -048 233 49                      10  002   0000000 00ML00MN
SFA  6708050808P                                     10415
SFA   W  0473KM          251 49                      10 -054   0000000 00ML00MN
EMM  6708050808P   09344                             10431
EMM   SW 0477KM 10 -078 205 49                      10 -010   0000000 00ML00MN
MIM  6708050808P   09361                             10494
MIM   SW 0492KM 10 -086 221 49                      10  221   0000000 00ML00MN
SCH  6708050808P   10016                   11117    11445  040  95  23
SCH   N  0699KM 10 -065 350 49                10  215 10  013   0000380 40ML34MN
            Z


+49.303- 65.873F MN=4.6 2239505 30091967 00.0260.047 0.3  9 21  81.65 218.00   0 1ML=5.2  10  0 3.62
$ CEEF EPICENTRE: 49.48N 65.78W   MN = 4.7
$ BCIS HAS EMERGENT PHASES FOR NINE OTHER DISTANT US STATIONS
$ NO MAGNITUDE DATA FOR SFA OR WES
$ SCB MAGNITUDE DATA NOT USED IN CALCULATION: SCB ALWAYS TOO HIGH
$ SCB MAGNITUDE DATA: 050  13 185  CALCULATES ML=6.5; MN=5.5
$ FORCING THE SOLUTION TO FIT HAL AND WES SN PHASES MOVES THE EPICENTRE SLIGHTLY TO
$    THE WEST, BUT RESIDUALS ON HAL AND WES ARE STILL ON THE ORDER OF 2 TO 3 SEC,
$    AND RESIDUALS ON OTHER STATIONS GENERALLY WORSE.
$ HAL SN CHECKED ON RECORDS
$ SIC RECORD NOT FOUND
$
SFA  6709302239P   40508          X41035      41350   41520


SFA   SW 0441KM 10  078 238 49    00  180    10  111 10 -043   0000000 00ML00MN
HAL  6709302239P   41020                      41532   42255  050  51 400
HAL   S  0547KM 10 -097 161 49                10 -328 10  373   0009856 52ML46MN
SCH  6709302239P   41126          X41320      42130   42420  040  94 532
SCH   N  0617KM 10  101 355 49    00  183    10  149 10  082   0008890 53ML47MN
MNT  6709302239P   41238                      42342           030  94 540
MNT   SW 0722KM 10 -043 237 49                10  062           0012032 54ML49MN
OTT  6709302239P   41407                      43050  X43490   050  46 253
OTT   SW 0861KM 10 -054 243 49                10  175 00  057   0006912 56ML48MN
WES  6709302239P   41434                      43044           050 074 145
WES   SW 0878KM 10  013 211 49                10 -240           0002462 52ML44MN
STJ  6709302239P   41568                      43310  X44232   050  84  65
STJ   E  0991KM 10 -024 096 49                10  018 00 -102   0000972 50ML41MN
GWC  6709302239P   42026                      43406  X44386   050  86 235
GWC   NW 1048KM 10 -143 314 49                10 -240 00 -145   0003434 56ML47MN
SCB  6709302239P   42205                      44170  X45220
SCB   SW 1197KM 10 -172 244 49                10  225 00  077   0000000 00ML00MN
FBC  6709302239P  X43093                      X45468  X47158   050 110  59
FBC   N  1616KM 00 -405 355 49                00  284 00 -126   0000674 54ML43MN
            Z


+50.210- 67.077F MN=3.6 1004465 29091968 00.0220.054 0.2  6 14  71.46 2 0.00   0 1ML=3.9  20  0 3.62
$ CEEF EPICENTRE: 50.14N 67.22W
$ CEEF MN = 3.6
$ GWC PN UNCERTAIN AT 06054
$ MNT ONSETS GOOD
$ SIC FADED AFTER P, SFA FADED
$ SCH PHASES REREAD
$ NO MAGNITUDE DATA FOR SIC
$ NOT RECORDED AT STJ
$ SIC RECORD NOT AVAILABLE
$ FITS SUBSTANTIALLY BETTER AT 0 KM
$ POSSIBLE BLAST BUT NO DATA TO CONFIRM OR DENY THIS
$
SIC  6809291004P                   04491
SIC   E  0025KM          100-90    10 -146                          0000000 00ML00MN
SFA  6809291004P                   05567     06343   06475  020  55  25
SFA   SW 0441KM          220-90    10 -099   10  119 10 -086   0001428 37ML36MN
SCH  6809291004P   05569           06092     06484   07100  040  83  66
SCH   N  0514KM 10  001 002 49     10 -024   10 -026 10  151   0001249 41ML37MN
HAL  6809291004P   06140                     07215   07565  040  66  10
HAL   SE 0673KM 10 -231 156 49                10 -105 10  391   0000238 38ML32MN
MNT  6809291004P                             07320  X08015   050 116  50
MNT   SW 0717KM          226 49              10  018 00 -312   0000542 43ML36MN
OTT  6809291004P                                    X08370   050  48  23
OTT   SW 0840KM          234 49                     00 -154   0000602 46ML37MN
GWC  6809291004P                             08139   09000  050  78  40
GWC   NW 0915KM          312 49              10 -016 10  052   0000644 47ML38MN
WES  6809291004P                                    050 074 010
WES   S  0930KM          202 49                     0000170 41ML33MN
            Z
```

#67a

#67b

#67c

#68

APPENDIX F

FELT REPORTS OF THE 5 JULY 1961 EARTHQUAKE
(NEAR PORT-CARTIER, QUÉBEC)

Estimated Mercalli Intensity

Sept-Îles

IV

1. Felt while sitting in new, well-constructed wooden house on sandy ground. Houses shook. Chairs, tables and chandeliers were observed swinging and shaking. No damage. Many alarmed.
2. Objects were observed swinging in a north-south direction. Many thought it was a dynamite explosion.
3. Felt while walking on second storey of a old wooden house on sandy ground.
4. Shock lasting about 30 seconds was felt while sitting on the first floor of a poorly constructed, old wooden house on sandy ground. No damage.
5. Rumbling felt while sitting on first floor of a new, two-storey wooden house on the shore. Most people thought it was a blast.
6. Felt while standing on first floor of an old one-storey house. Sounded like the rumble of a very heavy tractor.
7. Rapid onset of trembling felt while sitting on first floor of a two-storey, new, wooden house. No damage.
8. Felt while sitting. Motion generally south to north. Few alarmed.
9. Trembling felt while sitting. Loud thunderous noise similar to dynamite blast except for duration. Objects vibrated, but were not displaced. No panic.
10. Trembling with gradual beginning lasting about 20 seconds felt while walking in basement of a well constructed church. Accompanied by thunderous sounds. Many alarmed. No damage.
11. Felt while walking in a new wooden building. Moderately loud thunderous sounds. No damage. Few alarmed.
12. Felt while standing outside on a hill. Trembling in westerly direction. Few alarmed.
13. Sea observed with binoculars but no tidal disturbances noticed. Sounded like faint roaring increasing and decreasing as if travelling from southeast to northwest. Chairs, kitchenware and window sashes trembled. Pictures on north-south wall had north end

lowered about one inch. Objects shaken for approximately 15 to 20 seconds.

14. Violent trembling felt while sitting in a new, well-constructed brick building on second floor. Many alarmed.
15. Same as 14. Felt like a washing machine going out of order. Attributed to construction blasting.
16. Felt while standing in centre of wooden floor on first floor of a house with a concrete basement. Floor shook vertically. Slight alarm - mostly curiosity.
17. Shaking as if house was going to fall apart felt on first floor of a two-storey brick building on sandy ground. Swaying in westerly direction.
18. One shock lasting about 30 seconds was felt. Many people were afraid.
19. Felt while walking outside. Few were panicky but many alarmed.
20. Trembling lasting about 5 to 10 seconds felt while sitting on first floor of a two-storey wooden house.
21. Felt while walking in a new, one-storey brick house on sandy ground. Ground had undulation motion. Moderately loud rattling and bumping sounds. China and glassware moved but no damage. Thought by some to be abnormal blasting.
22. Felt while sitting on first floor of a one-storey brick building. Objects were displaced. Many alarmed.
23. Trembling from northwest to southeast felt while having supper. Objects on table rattled and furniture shaken slightly. One guest in the house thought that the furnace was exploding. Some thought that blasting was in progress. One recognised the shaking and noise to be that of an earthquake.
24. Felt while riding in an automobile on sandy ground. No panic or alarm - general curiosity.
25. Same as 24 except on a paved road. Few alarmed.
26. Felt while walking on first floor of a new wooden building. Loud sounds - like prolonged blasting.
27. Trembling felt on first floor of a three-storey, new brick house. Nothing disturbed. Many alarmed.
28. Felt while sitting on first floor of a two-storey brick building.
29. Trembling felt outside while eating. Surprise only.

Tika (Mile 57 on the railway to Schefferville)

IV

1. Series of rapid shocks were felt while sitting in a new wooden one-storey house on rocky

ground. Windows and furnace shook.

Trailer Camp (Moisie Valley, 15 Miles North of Sept-Îles)

III

1. Felt while walking in a trailer. No one in the trailer camp was afraid. It was thought that the trembling was due to a passing train.
2. Continuous vibration and rumbling lasting one minute felt while sitting in a trailer. People were surprised.
3. Rapid trembling felt while standing inside a railway boarding car in trailer camp. A hanging lamp rattled. Few were alarmed.
4. Felt while sitting inside and old boarding car (steel and wood). Car sitting approximately north-south appeared to sway east-west.
5. Trembling towards the north lasting 10 seconds was felt while lying down in a boarding car.
6. Brisk vibration was felt while walking in a wooden camper. The sound was like a tractor passing by only a few feet away. Surprise only.

Port Cartier

V

1. Rocking in northeast by southwest direction was felt while sitting in new mobile trailer. Several objects disturbed. Trees swayed. Rock fall at mile 12.3 was observed immediately following the quake but was not observed falling. Quake seemed to last for approximately 40 to 45 seconds.
2. Trembling lasting about a minute was felt while sitting on the first floor of a new, two-storey, wooden house. No damage.
3. Trembling appearing to run north and south was felt while sitting. Moderately loud thunderous sounds with the first shocks but diminishing as the trembling eased. General impression was that the furnaces were going to blow up. Everyone on the street ran out of their houses within seconds of the first shock.

Rivière-Pentecôte

III

1. Felt while sitting eating dinner. At first thought that the furnace was starting up, but then realised that it was an earthquake.

Baie des Homards

III

1. Felt while walking on the first floor on a two-storey wooden house. Shock lasted two minutes. Thought at first that it was the furnace, then thought it was an explosion.

RCAF Station Moisie

III

1. Felt while standing outside on a sports field on sandy ground. Trembling and faint rumbling were observed.
2. Felt while sitting inside a new, wooden, one-storey building. Few doubtful of positive ground movement.
3. Felt on the second floor of a two-storey wooden house. Thought to be dynamite explosion.
4. Trembling felt inside Armco building, a one-storey building. One loud rumble of short duration was noticed.
5. Trembling lasting approximately 2 to 10 seconds was felt while sitting in a one-storey house.

Sacre-Coeur – No Information.

Matane – Not Felt.

Havre-St-Pierre – Not Felt.

Godbout – Not Felt.

Premio (Mile 79) – Not Felt.

Mile 169 – Not Felt.

Lac Jeannine Yard (near Gagnon) – Not Felt.

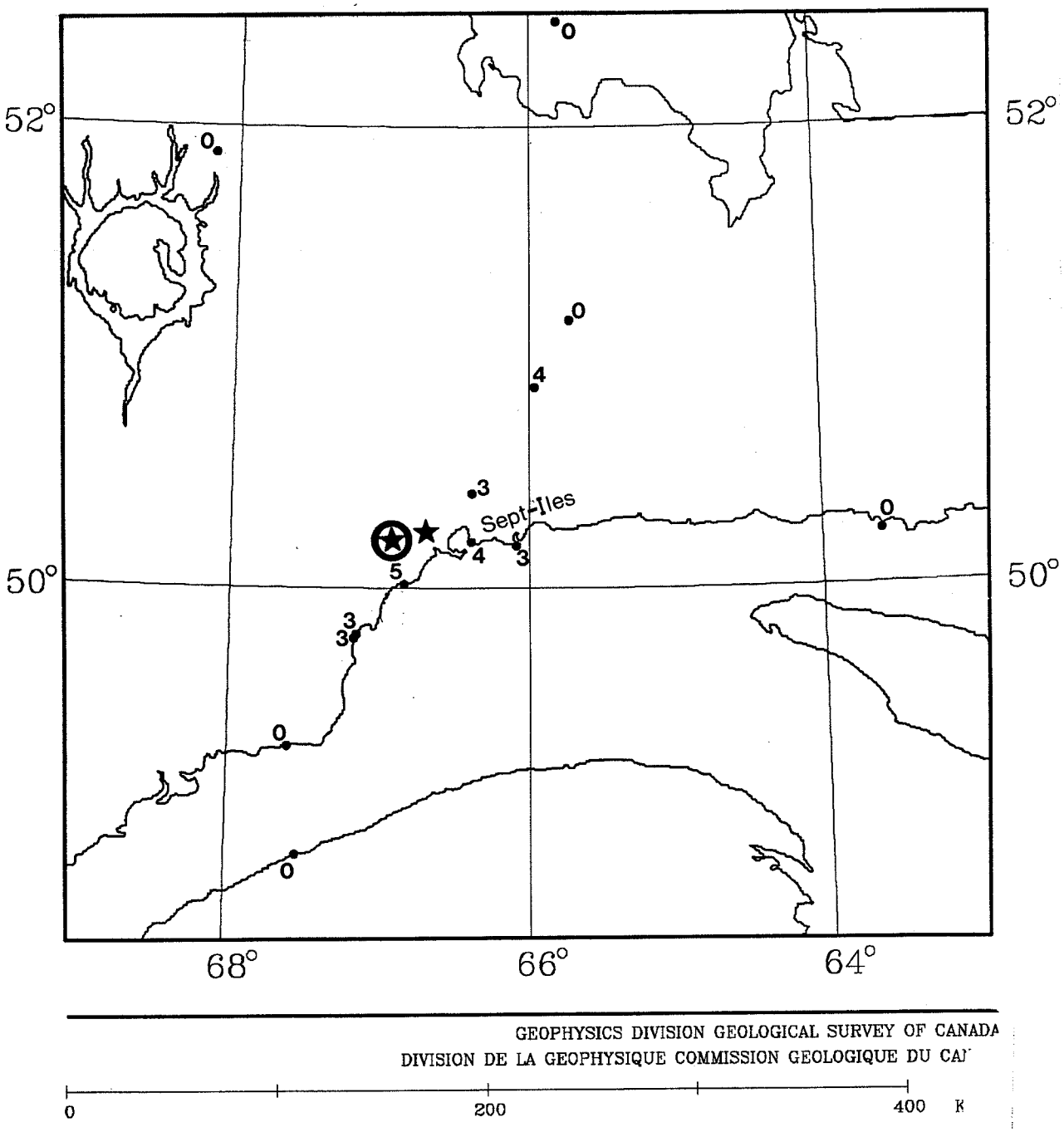


Figure. Modified Mercalli intensities for the 5 July 1961 earthquake near Port Cartier, Quebec. Star represents the old epicentre; Circle-star, the revised epicentre.