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Note added "in proof"

This report was substantially (98%) completed in August 1988, soon after Andrew Vonk's work term ended. While waiting for the figures to be drafted (the old fashioned way, using people, tracing paper and ink), Adams revised some of the epicenters and completed the manuscript. By the time the figures were available, the 1988 Saguenay earthquake had occurred, and Adams had moved on to other projects, and never requested translation of the abstract into French. In Spring 1989 the work was presented at the Annual Meeting of the Seismological Society of America (oral talk and printed abstract). The manuscript then sat for eleven years, until the magnitude 5 "millennium" earthquake in the Kipawa zone on 2000 01 01. At that point it was dusted-off and circulated as background information, and then returned to its dusty filing drawer.

The current thrust to publish the manuscript is owed to a request for information from Jeff Harris, GSC, who in a twist of fate, had been my summer student in 1980.

The version here is almost identical to the hard-copy completed on 1988 08 24. A few of the earthquake data files were updated or added in Fall 1988, and this may result in some slight inconsistencies in the text. The text was converted from "tex" to "Microsoft Word" and the "in press" references were updated to reflect the published versions, all done in winter 2008. It proved too labor-intensive to convert the tex tables into Word, so they are included as scanned images.

To my mind the text still reads well and contains a great deal of previously-unpublished information on the 1935 Timiskaming aftershocks and nearby pre-1989 earthquakes, as well as their relationship to local geological structures. Of course many more earthquakes have been located since then, and both the 1935 mainshock and the 2000 earthquake have been the topic of published papers (see below). The reader is warned that the Open File you hold in your hands (or read on your laptop, or listen to on your ipod) should be considered to reflect the state of knowledge in 1988, and not as of its publication date.

John Adams
2009 06 02

Further reading

Adams, J, and Vonk, A., 1989. The November 1 1935, M 6.2 Timiskaming earthquake, its aftershocks and subsequent seismicity, and some comparisons with the 1988 Saguenay earthquake (abstract). Seismological Research Letters, v. 60 part 1, p. 19.

Bent, A.L. (1996). An improved source mechanism for the 1935 Timiskaming, Quebec earthquake from regional waveforms, *Pure Appl. Geophys.*, 146, 5-20.

Bent, A. L., M. Lamontagne, J. Adams, C. R. D. Woodgold, S. Halchuk, J. Drysdale, R. J. Wetmiller, S. Ma and J.-B. Dastous (2002). The Kipawa, Quebec "Millennium" Earthquake, *Seism. Res. Lett.*, 73, 285-297.

ABSTRACT

The November 1, 1935 Timiskaming earthquake, m_b 6.2, was felt over an area of 1.3 million km^2 and was the first recorded from the Timiskaming area. This report documents the seismic history of the area with specific reference to the mainshock, immediate aftershocks, subsequent seismicity and seismotectonics. A new epicentre at 46.885°N 79.004°W has been determined for the mainshock. Seven new aftershocks that were reported in the national press are documented along with the twelve already known. The largest aftershock (m_N 4.9) lies 30 km northeast of the mainshock. Relocation of the subsequent earthquakes suggests that most of the earthquakes lie in a northwest-southeast trending band approximately 10 km wide and 55 km long under Lac Kipawa, here called the Kipawa Seismic Zone. Recurrence rates (β=0.92; N_0=2.0 per year) calculated for the zone have an extremely low β value and imply M=5.0 earthquakes once every 48 years. Available data provide poorly-constrained focal mechanisms for the zone. The best choice suggests thrusting on planes striking northwest and dipping about 45°, probably related to Lower Paleozoic rift faults that extend from the Ottawa Valley to Lake Timiskaming.

RÉSUMÉ

Le 1er novembre 1935, le séisme du Témiscamingue (m_b = 6,2), le premier enregistré dans la région, a fait trembler la terre sur 1,3 million de kilomètres carrés. Le présent rapport porte sur l'histoire sismique de la région et, plus particulièrement, sur la secousse principale, les répliques immédiates, la sismicité subséquente et la sismotectonique de la région. Un nouvel épicentre a été attribué à la secousse principale par 46.885° N 79.004° O. Le rapport présente douze répliques connues et sept nouvelles qui ont été signalées dans les quotidiens du pays. La principale réplique (m_N = 4,9) s'est produite à 30 km au nord-est de la secousse principale. Le déplacement des séismes subséquents laisse supposer que la plupart des tremblements de terre ont suivi la zone sismique de Kipawa, soit une bande d'environ 10 km de largeur et de quelque 55 km de longueur qui s'étend du nord-ouest vers le sud-est sous le lac Kipawa. Les intervalles de récurrence calculés pour la zone (ß = 0,92; N_0 = 2,0 par an) présentent une valeur ß extrêmement faible et impliquent des séismes de M = 5,0 à tous les 48 ans. Les données disponibles indiquent que les mécanismes focaux de la zone sont mal délimités. Les meilleures données laissent croire à un chevauchement sur des nappes orienté vers le nord-ouest, incliné à environ 45° et probablement lié à des failles de rift du Paléozoïque inférieur qui s'étendent depuis la vallée de l'Outaouais jusqu'au lac Témiscamingue.

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INTRODUCTION

In 1896 the Quebec part of the Timiskaming region was opened up by the construction of the Canadian Pacific railway through the area to Ville Marie. Settlement in Témiscaming began around 1917 when the Riordan Pulp and Paper Company opened a mill in the town (Canadian Encyclopedia, 1985, p. 1800). Apparently no earthquakes were felt or recorded in the 18 years prior to November 1, 1935. It was thus a shock when the M 6.2 earthquake occurred, and the nature of the seismicity and its tectonic and structural implications are still not understood.

Relatively few earthquakes have been recorded since the Timiskaming mainshock and its immediate aftershocks; eight between the years 1937 and 1979 and seven since 1980. The ability of the Canadian Seismograph Network to locate smaller earthquakes in the region has improved over the decade 1978-1988 with the addition of seismograph stations at Val-d'Or (VDQ, December 1980 – April 1986), Eldee (EEO, March 1984 – present) and Chalk River (CKO from January 1981; later replaced by the nearby station CRLO). Prior to the improved monitoring it is probable that many smaller earthquakes occurred but were not detected or could not be properly located.

This report documents the seismicity in the Timiskaming area and presents relocations of all the known earthquakes. The new epicentral pattern and some preliminary earthquake focal mechanisms are used to interpret the seismotectonics of the region. It is proposed that a new seismic zone, the Kipawa Seismic Zone (KSZ), be defined for the region of seismicity near the Timiskaming mainshock.

Study of the Timiskaming mainshock and subsequent seismicity is important because the earthquake is one of the five largest earthquakes in southeastern Canada and it lies at one end of a Paleozoic rift fault system along the St. Lawrence and Ottawa rivers which appears to be controlling the seismicity of southeastern Canada (Adams and Basham, 1989). Thus an understanding of the nature and cause of these earthquakes will aid our interpretation of other earthquakes along the St. Lawrence system.

Toponomy

In varied spellings ‘Timiskaming’ (“from the Indian ‘at the place of deep dry water’ in reference to the clay flats in the lake which dry up at low water” – Harder 1976) refers to a lake (Lake Timiskaming, Ontario = Lac Témiscamingue, Quebec), a county (Témiscamingue, Quebec), a district (Timiskaming, Ontario), a First Nations reserve (Timiskaming, Quebec), and to a town, (Témiscaming, Quebec). There is also an obsolete English spelling, ‘Temiskaming District’. The 1935 earthquake was originally termed the Timiskaming Earthquake and was named after the town (then spelled) Timiskaming, Quebec (Hodgson, 1936a), although it should be noted that a map in the same paper gives the spelling of both lake and town as ‘Temiskaming’.

In view of the multiplicity of names and the ambiguity of their usage, we have adopted ‘Timiskaming' for the spelling of the study area and ‘Témiscaming' for the town.

REGIONAL GEOLOGY AND SEISMICITY

The Timiskaming Region and the Kipawa Seismic Zone lie within the Ontario Gneiss Belt of the Grenville Province of the Canadian Shield (near the circled star on Fig. 1). The Ontario Gneiss Belt consists principally of quartzo-feldspathic gneisses of upper amphibolite to granulite metamorphic grade. Together with the Quebec Gneiss Belt to the east, it is considered the basement for the sediments of the Grenville Supergroup (Central Metasedimentary Belt) which were deposited in the early Proterozoic. The sediments were metamorphosed into marbles, quartzites and paragneisses and deformed by the Grenville Orogeny approximately 1100 Ma ago (Doig, 1977).

North of Témiscaming is the Grenville Front, the 1100-Ma-old suture between the older Superior Province to the north and the Grenville Province to the south. The Grenville Front is approximately 1900-km long, running east-northeast from Lake Huron, through central Ontario and Quebec to Labrador. It consists of stacked southeast-dipping thrusts (A. Green pers. comm., 1988).

The Grenville and Superior provinces were rifted in the late Precambrian – early Paleozoic, during the opening of the Iapatus Ocean along the line of the present St. Lawrence Valley. The Ottawa-Bonnechere graben, one branch of the "St. Lawrence Rift System", was shown by Kumarapeli and Saull (1966) to further bifurcate near Mattawa, Ontario. One branch extends west through Lake Nipissing and the other branch extends northwest through Lake Timiskaming and the study area of this report. Related structures may extend from Timiskaming northwest to Kapuskasing, Ontario (Forsyth et al., 1983). At the north end of Lake Timiskaming these rift faults offset Silurian strata and so were active less than 425 million years ago (Lovell and Caine, 1970).

Lovell and Caine (1970) define a distinct topographic feature consisting of a set of long parallel NW-SE trending faults from Témiscaming to Kapuskasing as the Lake Timiskaming Rift Valley (Fig. 2). They drew similarities between the structure of the Lake Timiskaming area and the African Rift System and postulated that the Timiskaming earthquake occurred along one of these faults.

A significant cluster of earthquakes – the Western Quebec Seismic Zone (WQU) of Basham et al. (1982) – occurs in the Grenville Province of the Canadian Shield, predominantly in western Quebec but extending into eastern Ontario across the Ottawa River (Fig. 3). In addition to the Timiskaming earthquake, an earthquake with magnitude about 6 occurred at or near Montreal in 1732 and one of 5.6 occurred near Cornwall, Ontario in 1944.

The northern boundary of the Western Quebec Seismic Zone was drawn by Basham et al. (1982) based on the location of the Timiskaming mainshock, of the magnitude 4.9 aftershock (on November 2, 1935), and of a magnitude 5 earthquake near the headwaters of the Gatineau River in 1950, well outside the study area.

In detail (Fig. 3), the seismicity appears to occur in two bands. The first band, trending slightly west of northwest, lies along the Ottawa River from Lake Timiskaming to Ottawa and thence widens to extend southeast to Cornwall and east to Montreal. It includes the larger earthquakes near Timiskaming (1935, 1982), Rolphton (1963), North Gower (1983), Cornwall (1944, 1981) and

Montreal (1732). The second band, containing more but smaller earthquakes, trends slightly north of northwest and extends from Montreal to the Baskatong Reservoir, about 200 km north of Ottawa. It may be due to crustal fractures formed during to the passage of North America over a hotspot between 140 and 120 million years ago (Adams and Basham, 1989).

The 1978-1988 decade of monitoring by the Eastern Canada Telemetered Network (ECTN) shows the gap between the two bands is reasonably well defined at the northwestern end by an absence of M=3 earthquakes and a relative paucity of small earthquakes (Fig. 3). Forsyth (1981) has shown that the earthquakes in the first band, including the larger historical earthquakes, may be associated with the rift faults along the Ottawa River. Although the last time of normal movement on these faults is not known, there is tenuous evidence that they might have been reactivated in the Mesozoic during the initial opening of the North Atlantic, as shown by Jurassic kimberlites in Ontario and New York State. However, if the rift faults underwent a major reactivation in the Mesozoic, it is surprising that so little hard evidence has been found. Regardless of age, the seismicity between Timiskaming and Cornwall, and some recent focal mechanisms of moderate earthquakes (Adams et al., 1988), suggest the Ottawa Valley rift faults are seismically active.

MAINSHOCK PARAMETERS

The Timiskaming earthquake occurred on the morning of November 1, 1935 just after 1 a.m. Eastern Standard Time. A synopsis of the felt reports as reported in the Dominion Observatory records and the Scrapbook is listed in Appendix A. Figure 4 shows the isoseismal map compiled by Smith (1966).

Four groups have computed a location for the mainshock (Table 1, Fig 5). The first group was directed by Dr. E. Hodgson of the Dominion Observatory in Ottawa. He originally used seven seismograph stations: Ottawa, Shawinigan Falls, Harvard, Buffalo, Chicago, St. Louis, and Washington (Hodgson, 1936a). The epicentre was located at 46°45'N 79°15'W (46.75°N 79.25°W), assuming an origin time of 06:03:40 U.T. and a depth of 200 km because of the wide felt area. Based on the above knowledge, Dr. Hodgson began a field survey in the Timiskaming area. A new tentative location was determined on the basis of the field work at 46.78°N 79.07°W, with the same origin time and depth. It appears that this new location was chosen for two reasons (Hodgson, 1936b): firstly, that rails along the Kipawa-Dozois Canadian Pacific railway moved towards this point; second, that the waters of nearby Lac Tee (Tee Lake) became muddied after the earthquake (see also Shilts, 1984).

The International Seismological Summary Bulletin (ISS) of 1935 gave the epicentre at 46.8°N 79.2°W, with the same origin time and depth 'normal' (33 km), based on 98 stations. Two other locations have also been determined. A new location by Gutenberg and Richter (1949) set the earthquake at 46.8°N 79.1°W, at a depth of 60 km, with the same origin time as Hodgson. The final location, to date, was done by Dewey and Gordon (1984). They fixed the depth at 1 km, and used a joint hypocentre program to determine an origin time of 06:03:34.2, (six seconds earlier than any previous estimate), and an epicentre at 46.874°N 79.051°W, with an 80% confidence that it lay within 12 km of that point.

Data used for the current location were obtained from ISS and Dominion Observatory records. The ISS readings were confirmed by Lehmann (1955). Original records for the Canadian stations and copies of foreign stations were assembled by Hodgson in 1936. The available local seismograms were examined and no major discrepancies were found. Seventeen stations were used in this location, all within approximately 2000 km of the epicentre, with Saskatoon being the farthest. Sixteen of these stations showed small residuals for both Pn and Sn phases after recomputation of the epicentre using standard Geophysics Division earth models and computer program (LOC). The velocities used in 'LOC' are crustal Pg and Sg (and/or Lg) velocities of 6.2 and 3.65 km/s and mantle Pn and Sn velocities of 8.2 and 4.7 km/s, the Lg velocity being the revision proposed by Wetmiller and Cajka (1988) to the previous standard velocity of 3.57 km/s. Only the phases from Little Rock (LRA) could not be used. Later S phase arrivals (Lg) were probably hard to read because seismographs went off scale due to the size of the earthquake.

There were no close stations (OTT is at 300 km) and no reliable crustal phase readings for this earthquake; therefore, it is impossible to determine the depth of the earthquake directly and a substantial tradeoff occurs between depth and origin time. This is seen by the range in the depths adopted by different authors. We have fixed the depth at 10 km for three reasons: firstly, 10 km is half of the thickness of the seismogenic upper crust in most of southeastern Canada (i.e. 10 ± 10 km; Adams and Basham, 1989); secondly it is in accord with the modeling of teleseismic phases of Ebel et al. (1986) who derived 10 ± 2 km; and finally 10 km is the suggested minimum depth of M >6.0 earthquakes in eastern North America (Acharya, 1980) if surface faulting is to be absent.

Computation of the epicentre with 23 good phases from the 16 stations gives an epicentre at 46.885°N 79.004°W, with and error of about ±5 km. The origin time was found to be 06:03:36.7, approximately halfway between that of Hodgson (1936a) and Dewey and Gordon (1984). Our new epicentre lies 13 km northeast of Hodgson's second location. Hodgson's field evidence suggested an epicentre to the northeast of Témiscaming and southwest of the Canadian Pacific Railway because spare rails apparently moved towards this point. Our new epicentre lies 19 km northeast of Témiscaming but is 10 km northeast of the railway. It lies 3.8 km northeast of the Dewey and Gordon location, though if our depth were set at 1 km, the epicentre would move to within 2 km of the Dewey and Gordon position and the origin time would change to 06:03:35.7. Again it must be mentioned that the assigned depth is arbitrary. Surface faulting *might* have been expected for this earthquake if it was shallower than 10 km, but none was seen.

Various magnitudes have been determined for the mainshock (Table 2). We adopt a magnitude of m_b=6.2 as the average between the Street and Turcotte (1977) and Ebel et al. (1986) values for m_b. A seismic moment of 5 x 10^{25} dyne-cm was determined by Ebel et al. (1986).

AFTERSHOCKS

The Canadian Earthquake Epicentre File, and Smith (1966), show 12 aftershocks recorded by Canadian stations in the six months following the mainshock. A new examination of newspaper clippings in the Dominion Observatory Scrapbooks shows that at least 7 other aftershocks were felt by residents in and around Témiscaming and were reported in the national press (Table 3). For some of these, we were able to find traces on the existing seismograms to enable calculation of an origin time and magnitude.

The strongest aftershock (m_N = 4.9) occurred on the morning of November 2, at 14:31:54.2 U.T., 32 hours after the mainshock. It was widely felt, as far as Kitchener, Ontario, and State College, Pennsylvania (Smith, 1966). Our relocation confirms Smiths' (1966) conclusion that this earthquake did not have the same epicentre as the mainshock and is probably best termed a "displaced aftershock'" or a "related earthquake" rather than a true aftershock. A recent similar occurrence was the Trousers Lake earthquake which occurred 30 km west of, and six months after, the Miramichi mainshock (Wetmiller et al., 1984). The new epicentre for the November 2 earthquake – 46.98°N 78.51°W – was determined as for the mainshock, using eight stations with 10 phases and a fixed depth of 10 km. It lies approximately 30 km east-north-east of the new mainshock epicentre. Smith (1966) had located the event at 47.23°N 78.28°W, which was approximately 80 km away from where he placed the mainshock. The magnitude of m_N 4.9, determined using the three Canadian stations, is less than the magnitude of M_L 5.4 determined in 1935 and is consistent with the way M_L overestimates the magnitude of eastern North American earthquakes (see Appendix C of Basham et al., 1982).

Eleven other aftershocks registered on one or more of the Canadian seismographs before the end of April, 1936. It is impossible to determine individual locations for these events because many were recorded on only one station, mainly SHF. Although OTT was closer, it was operating only Milne-Shaw instruments with a gain of 300, and did not record some of the small aftershocks. SFA was farther away. It is frustrating that some aftershocks of about magnitude 4 were recorded on one station (often SHF), but not on the other two, while larger aftershocks did not record on SHF but did on one of the others. The four aftershocks recorded only at OTT in Table 3 were assigned magnitudes and intensities by Smith in his card file "judged by the OTT MS" and cited as "estimated M_L" in Smith (1966). Despite the assigned intensities, it is not clear that these earthquakes were felt, and our rough measurements from the original records indicates magnitudes of nearly m_N 4, which is consistent with the ten-times-larger amplitude on the OTT Milne-Shaw for the large aftershock on 19351102 at 14:31 UT. The revisions from "estimated intensity"-derived magnitudes to instrumental magnitudes increases the size of the aftershocks from ~M2-M3 to ~M4, and suggests that the assigned magnitude of 3.0 to the felt earthquakes without instrumental data (in Table 7) is conservative. Although they lack an instrumental record, most of the aftershocks were felt in the Timiskaming area (Hodgson, 1936a,b), confirming their general location. All of the aftershocks were assigned to the hypocentre of the mainshock to determine their origin times and magnitudes.

A magnitude-time plot is given for the aftershocks on Figure 6. A slight decline in the magnitude of the largest aftershocks is seen with time, and doubtless many small earthquakes were felt but not reported after the initial period of interest.

SUBSEQUENT SEISMICITY

Between May 1936 and June 1988 there were 15 earthquakes in the Kipawa Seismic Zone, the first few of which might be considered as aftershocks. Appendix B gives the revised PIK files in the same format as for the mainshock and vectors on Fig. 5 shows the direction and distance of the relocations.

Epicentres of pre-1975 earthquakes were revised by using the phases read by W.E. Smith and other Dominion Observatory seismologists (as are recorded in Smith's card catalogue and on punched cards), and additional local phases reported by the ISS/ISC, in the Geophysics Division's current location program ‘LOC’. In some cases critical phases were re-read as noted in the comments in Appendix B. The 1982 earthquake was relocated by re-reading all analog and digital data. Depth was set at 10 km for all earthquakes.

The 1937, 1938, and 1940 earthquakes were all felt in Timiskaming but recorded only on OTT; they have been assigned to the revised mainshock epicentre. Note that Smith (1966) had placed these earthquakes at the town of Témiscaming, and not at his mainshock epicentre. The 1944 earthquake was felt in Témiscaming, but our revision moves it further from the town than Smith's epicentre. The 1952 earthquake was also felt in Témiscaming, but our revision moves it closer to the town than Smith's epicentre, and this is more consistent with the felt report (MN 3.6 felt at 20 km rather than 60 km). The 1961 earthquake was felt in Témiscaming, (most strongly near Lac Tee)
but recorded only by OTT; we have assigned it to the mainshock location.

The 1965 earthquake was relocated approximately 40 km to the southeast of its catalogued location, due to the rereading of the LND phase. The new epicentre is closer to North Bay, where it was widely felt (Smith and Milne, 1970). This event was not used in the calculation of recurrence rates and is not plotted on the revised seismicity maps in this report. For the 1975 and 1980's earthquakes the revised epicentres differ from the routinely-located epicentres by less than 10 km, with the exception of 1982 (due to re-reading of all phases and not using distant stations for the solution) and 1988a (because the CKO first arrival had been misidentified as Pn).

Two earthquakes which occurred on 22 August and 11 October, 1988, during the writing of this report, are shown on Fig. 5 and are included in Appendix B. A third earthquake, on 15 October 1988, is included in Appendix B only. They have not been used in the recurrence computations, and are not shown on all of the appropriate figures.

A map of the revised seismicity is shown in Figure 7.

Six small events were detected on EEO since 1984 (M. Cajka, pers comm.) but could not be located (Table 5). Of the six, four have S-P intervals that could correspond to earthquakes in the KSZ (equivalent distance ~ 15 – 45 km). An approximate location was determined for the 29 Sept 1987 earthquake (Appendix B). The azimuthal coverage was poor with all stations being to the west. The location places the earthquake 19 km to the southeast of EEO, but with an uncertainty of 20 to 30 km. Although this event could be within the KSZ, it is considered too poorly located to have been included in the above discussion. One of the six events gave a compressional and three gave dilatational first motions on EEO.

Rate of Seismicity

Figure 8 shows a plot of the Kipawa seismicity against time together with the magnitude thresholds achieved by the Canadian Seismograph Network for the seismic zone. The thresholds were determined by using "LOC" to calculate the magnitude at each seismic station for an amplitude of 2 mm, the magnification factor of each seismograph at a period of 0.3 seconds, and a source at Lac Kipawa (Appendix C), and then accepting the smallest magnitude for the stations operating at the time as the detection threshold. The record of earthquakes plotting above the down-stepping line is thought to be "complete" (that is, such earthquakes are thought to have been unlikely to have been missed), while earthquakes below the line represent just some of the many smaller earthquakes.

The recurrence rates of earthquakes within the KSZ are calculated from the number of earthquakes larger than a certain size and the time over which such earthquakes are thought to have been completely recorded. Although there is an argument for excluding aftershocks from such a calculation, the displaced aftershock of November 2nd (at 14:31) has been included because its relationship to the mainshock is uncertain; other aftershocks are too small to pass the deduced completeness threshold (see Fig. 8). Figure 9 plots cumulative rate versus magnitude for all events (except the immediate aftershocks); the fitted line has the equation:

$$N=M = 2.04e^{(0.918M)}(1 - e^{-0.918(7.0-M)}).$$

The maximum magnitude earthquake is assumed to be 7.0, but alternative curves for Mx of 6.5 and 7.5 are also shown. Appendix D gives the computed recurrence parameters for all three values of Mx. The cumulative rate of earthquakes for $M \geq 1.8$ (the current threshold to locate earthquakes) is predicted to be 0.4 per year. In other words, it is expected that a $M \geq 1.8$ event will occur once every 2.5 years. The annual rate for a $M \geq 5.0$ event is 0.0207, or once every 48 years. The slope is less steep than the slope determined by Basham et al. (1982) for the WQU zone, and may indicate a region of higher-than-normal stress. The β value is similar to that of the Northern Vancouver Island source zone (Basham et al. 1982) where a few large earthquakes and very few small earthquakes combine to produce a low β value.

SEISMOTECTONICS

Epicentral Distribution

Figure 10 shows the suggested shape and size of the Kipawa Seismic Zone (KSZ). A NW-SE trending rectangle 10 km wide and 55 km long encompasses all the seismicity except the largest aftershock. Also plotted are the error residuals of the earthquakes. The smaller error diamonds represent events that are located more accurately. Note the cluster of seismicity at the centre of the box and the fact that the elongation of the box is defined mainly by the one northern and two southern earthquakes.

Focal Mechanisms

Two possible focal mechanisms for the mainshock have been determined by Ebel et al. (1986) using body and surface wave modeling (Figure 11A). They determined that the earthquake represented predominantly thrust faulting on moderately dipping planes striking approximately 150°or 240°with likely error of ±15°–20° on each parameter. One station to the southeast (HRV) has an ambiguous first motion. The HRV long period waves clearly show a compressional first arrival but the short period waves show a high-frequency dilatational pulse (Ebel et al., 1986, figure 6). Although the modeling was ambiguous, Ebel chose the northwest-striking pair of planes and so inferred compression from the NE-SW direction.

Two other earthquakes were large enough for us to attempt focal mechanisms: 13 August 1982, m_N4.3 and 17 August 1987, m_N3.2. Two possible families of focal mechanisms; a thrust and a strike-slip were determined for the 1982 earthquake (Figure 11B). Seventeen P-wave first arrivals constrain the planes, with the change from dilatations to compressions in the eastern quadrant and the near-nodal CKO reading being the main constraints. The thrust mechanism misfits SUD to the west and QCQ to the east. The strike-slip mechanism shown is a median plane for a large family of strike-slip mechanisms that fit the eastern data. Only one station (EBN) misfits the strike-slip mechanism.

The 1987 earthquake also has two possible families of mechanisms, a thrust and a strike-slip (Figure 11C). Eleven P-wave first arrivals were recorded and there are no misfits for either family. One S/P amplitude ratio was calculated at Eldee (EEO) in the northeast quadrant. It should be noted that the two strike-slip solutions derived for the pair of earthquakes are very different and have only small areas of common polarities. They also imply different maximum horizontal compressive stress directions: 1982 – northeast-directed; 1987 – north-directed. By contrast the two thrust solutions for the pair of earthquakes are similar, and both indicate compression from the northeast.

Fourteen P-wave first arrivals were read for other small earthquakes (Figure 11D). Note the consistent dilatations for EEO that plot at the periphery of the northeast quadrant. Neither of the two strike-slip solutions fits all three dilatations. Most of the other arrivals appear scattered and do not define clear compressional and dilatational fields. The dashed focal plane plotted on Figure 11D represents the composite mechanism of Figure 11F. The EEO dilatations are consistent with this mechanism.

All polarity data as well as the three thrust mechanisms are plotted on Figure 11E. All three mechanisms have a common plane striking northwest and dipping to the southwest. A composite mechanism was computed using all the data (Fig. 11F). This mechanism represents the best-fit solution for this data set. A strike-slip solution is fairly well constrained if only the 1982 and 1987 data are used, but it misfits the mainshock data. The thrust solution satisfies most of the data including the mainshock data. A few misfit readings such as the 1982 eastern dilatations are present but they are close to the nodal planes; this event may have had a slightly different dip or strike for the NE-dipping plane.

The polarity data for these earthquakes is insufficient to determine unequivocally a mechanism for the Kipawa earthquakes. However, the data are consistent with thrusting on northwest-trending, moderately-dipping planes and thus agree with the surface-wave modeling results from the Timiskaming mainshock. Therefore, we consider that the thrust mechanism in Figure 11F is the best representation yet available. The ambiguities between thrust and strike-slip families of mechanisms might be resolved when a future moderate (M =3.5) earthquake occurs in the zone; by waveform modeling of the EEO time-series; or when small earthquakes in the southeast of the zone provide polarities on EEO and confirm whether or not the polarity change required across the NE-striking nodal plane of the strike-slip solutions occurs.

Stress Field

The chosen mechanism represents thrust faulting in response to compression from the northeast, and so is consistent with the regional stress field in eastern North America (Adams, 1988). The only direct measurement of stress close to the KSZ was made for Hydro-Quebec at the Lac Beauchêne Project, 10 km southeast of Témiscaming (Adams, 1987). From 14 measurements made in 3 boreholes drilled from a tunnel 60 m below ground level the following components of the stress field were determined: σ_H = 20 MPa at 105°; σ_h = 7.6 MPa at 015°; σ_v = 5.5 MPa. The measured stress field implies a thrust-fault environment but indicates compression from the east quadrant rather than from the northeast; topography and schistosity may have played factors.

Correlation with surface features

If the earthquakes had occurred at 10 km depth on the planar faults deduced from the composite mechanism, the surface projection would lie 8 km to northeast of the zone for the plane (plane A) striking 300° and dipping 50°SW, or 12 km southwest from the zone for the plane (B) striking 309° and dipping 40°NE. Lineaments on topographic maps and air photos suggest that two sets of roughly northwest-trending (310° and 340°) faults intersect under Lac Kipawa (Fig. 12, see also topographic features on Fig. 7).

Near Cobalt, the faults on the east side of Lake Timiskaming strike 320-325° and dip to the NE, as would be expected for rift faults. The McKenzie Fault (Fig. 2) dips 65°NE (Lovell and Caine, 1970) but might be expected to flatten at depth. The Montreal Fault, lying to the SW might also be expected to dip NE (eg. Lovell and Caine (1970) figure 2) and as this fault extends along strike to the southeast through Lac Kipawa, the 310°-trending lineaments might also be expected to dip NE. The trend of the KSZ mapped on Figure 10 is 328° (±15°), which is parallel to the faults on the southwest side of Lake Timiskaming. Lovell and Caine suggest the Timiskaming graben is bounded to the NE by the Quinze Dam Fault which strikes NNW and on rather less evidence they suggest it might dip SW, into the graben. The Quinze Dam fault projects through Lac Kipawa and so the 340°-trending lineament might be a fault dipping to the SW. Although this fault may dip in the same direction as plane A, it has a 40° difference in strike.

The agreement in strike suggests that plane B of the composite focal mechanism, which strikes 309° and dips 40°NE, is the most probable fault plane. This places the mainshock on a plane that projects to the surface between Lac Kipawa and Lake Timiskaming, and approximately on strike with the Montreal Fault and the straight section of Lake Timiskaming immediately downstream of the Montreal River outlet. The surface projection lies very close to both Lac Tee (where the lake-bottom sediment was highly disturbed) and the Kipawa-Dozois section of railway (where rails were shifted, see Fig. 5), raising the possibility that there was amplification of ground motion where the rupture was propagating up-dip to the surface.

CONCLUSIONS

- Based on an updated velocity model and a better depth estimate, a new location has been determined for the November 1, 1935 Timiskaming Earthquake, at 46.885°N 79.004°W, ±5 km.
- The origin time has been estimated as 06:03:36.7 U.T., or 1:03 a.m. E.S.T.
- The depth of 10 ± 2 km and seismic moment of 5 x 10^{25} dyne/cm are adopted from other authors, and the adopted magnitude of m_b 6.2 is the average from two other authors' values.
- At least 19 aftershocks were felt or recorded instrumentally in the first six months after the mainshock. Most of these were at least magnitude 3 with one event as large as m_N 4.9. The largest aftershock is located 30 km northeast of the mainshock and may best be termed a "displaced aftershock" or a "related earthquake" rather than a true aftershock.
- There is no history of seismicity for 18 years prior to the mainshock. To 1988, 15 earthquakes had been recorded since the mainshock and its immediate aftershock sequence.
- Recurrence calculations (β=0.92; N_0=2.0 per year) give an average rate for M = 5.0 of 0.0207 per year (once every 48 years on average). The rate of locatable earthquakes is once every 2.5 years on average. We have located earthquakes as small as m_N 1.8.
- Relocation of all seismicity within the area shows most earthquakes lie in a zone 55 km long by 10 km wide, trending 328°. More than four small unlocated events may have occurred within the zone in the period 1984-1988.
- The focal mechanisms of the mainshock and of recent small earthquakes are consistent with (but do not require) thrust faulting on northwest-trending fault planes. A composite mechanism incorporating all data suggests a thrust mechanism with a strike 120°, dip 50° and rake of 84°.
- A portable seismic network should be installed in the KSZ for a few weeks or a month to record microearthquakes. The network would provide accurate locations and depths as well as aiding in determining focal mechanisms. Based on an extrapolation of the recurrence relationship, magnitude 0 or larger earthquakes might occur every six months, although if the β value were larger, the rate would be considerably higher.
- A permanent seismic station just to the northeast of the area would supplement the data received from EEO and make it easier to locate KSZ events. Since the closure of VDQ, the closest station on this azimuth is JAQ (distance=800 km).
- A lineament study of the KSZ and immediate area would be useful to compare possible faults with the epicentral trends and the focal mechanisms. Such a study might decide if either or both of the NNW- or NW-trending faults are active, or whether it is the intersection of these trends under Lac Kipawa which is the most important factor.

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FIGURE CAPTIONS

Figure 1. Seismicity and geologic features in and near the Western Quebec Seismic Zone. Dashed lines indicate the northeastern limit of Paleozoic cover, while short dashes indicate geological province subdivisions in the basement (from Forsyth, 1981, Fig 1.)

Figure 2. Lake Timiskaming Rift Valley and associated structures according to Lovell and Caine (1970). The Kipawa Seismic Zone lies in the extreme bottom-right corner.

Figure 3. The Western Quebec Seismic Zone together with a suite of earthquakes chosen based on the improving detection ability of the seismic network: M=6.0 since 1900, M=5.0 since 1928, M=4.0 since 1937, M=3.0 since 1968, and M=2.0 since 1980. OTT, GAC, etc. represent seismometers, and the study area of this report is boxed.

Figure 4. Isoseismal map of the Timiskaming Earthquake (from Smith, 1966). Maximum felt intensity was Modified Mercalli Scale VII (see Appendix A for felt reports).

Figure 5. Revisions to the seismicity of the Kipawa Seismic Zone. Epicentres determined for the Timiskaming mainshock (see Table 1) are: 1: Hodgson 1936a; 2: Hodgson 1936b; 3: ISS; 4: Gutenberg and Richter (1949); 5: Dewey and Gordon (1984); 6: This Report (1988). Sections of the railway that shifted during the mainshock are shown by a heavier line. For subsequent earthquakes a vector joins the old (open symbol) to the revised (filled symbol) location, and the symbols indicate magnitude as on Fig. 3. Note the largest aftershock recorded on 2nd November at 14:31 moves southwest into the map area near its eastern edge and the 1965 earthquake moves off the map to the southeast.

Figure 6. Aftershocks of the Timiskaming Earthquake, 1 November 1935, displayed by plotting magnitude against time since the mainshock.

Figure 7. Revised seismicity of the Kipawa Seismic Zone superimposed on a topographic map base. Symbols as on Fig. 3.

Figure 8. Earthquakes in the Kipawa Seismic Zone, displayed by plotting magnitude against date. The down-stepping line represents the magnitude detection threshold determined in Appendix C and is labeled with the most sensitive station at each time (e.g. SUD).

Figure 9. Rate of seismicity in the Kipawa Seismic Zone shown as a cumulative plot of rate against magnitude. The maximum magnitude (Mx is taken to be 7.0, but the derived curves for 6.5 and 7.5 are shown dotted (see Appendix D).

Figure 10. Revised epicentres, errors and suggested boundaries for the Kipawa Seismic Zone. The error associated with each epicentre is shown as a diamond. The northwest-trending (328°) rectangle is suggested for the limits of the Kipawa Seismic Zone.

Figure 11. Focal mechanism solutions (lower hemisphere stereonets) for Kipawa earthquakes. Compressional first motion polarities are designated as C, dilatational first motions are D

(half-weight, small C and D), and S/P amplitude ratios are represented as various sized X's centered on the polarity. Pressure (P) Tension (T) and B axis are also plotted. **A:** mainshock solutions of Ebel et al. (1986). **B** and **C:** solutions for the 1982 and 1987 earthquakes. **D:** combined polarities from other earthquakes in the KSZ. The dashed line shows the best solution of F. **E:** thrust mechanisms from A,B and C, together with all polarity data. **F:** best composite focal mechanism solution for all the data.

Figure 12. Revised KSZ earthquakes superimposed on LANDSAT photograph. Note the intersection of the northwest– and north-northwest–trending lineaments at Lac Kipawa.

Table 1

Epicentres for the Timiskaming Earthquake, 1 November 1935

AUTHOR	LOCATION °N	°W	ORIGIN TIME (U.T.)	DEPTH (km.)
1. Hodgson (1936)				
- Location With Seven Stations.	46.75	79.25	06:03:40	200
2. Hodgson (1936)				
- Location After Field Work.	46.78	79.07	06:03:40	200
3. ISS (1935)	46.8	79.2	06:03:40	'Normal'
4. Guttenberg and Richter (1949)	46.8	79.1	06:03:40	60
5. Dewey and Gordon (1984)	46.874	79.051	06:03:34.2	1
6. This Report (1988)	46.885	79.004	06:03:36.7	10

Table 2

Magnitudes for the Timiskaming Earthquake, 1 November 1935

AUTHOR	TYPE	MAGNITUDE
Guttenberg and Richter (1949)	M_s	6.25
Street and Turcotte (1977)	M_s	6.1
Ebel et al. (1986)	M_s	6.0
Street and Turcotte (1977)	m_b	6.3
Ebel et al. (1986)	m_b	6.1
Atkinson and Boore (1987)	m_N	6.3
Ebel (1982)	M_L	>5.5

Table 3

Immediate Aftershocks of the Timiskaming Earthquake

Up To March 25, 1936

DATE	TIME (U.T.)*	MAGNITUDE (m_N)*	RECORDING STATIONS**	NOTES
19351101	17:01	4.2	SHF	Felt in Témiscaming
19351102	00:42	4.3	SHF	Felt in Témiscaming
19351102	13:51	3.1	OTT	Felt in Témiscaming
19351102	13:55	2.8	OTT	Felt in Témiscaming
19351102	14:31	4.9	OTT SHF SFA	Felt in Témiscaming Dispaced aftershock, (see text).
19351105	10:11	4.0	SHF	Felt in Témiscaming
19351105	14:15	F		Felt in Témiscaming and Widdifield. †
19351107	16:48	2.4	OTT	
19351107	?	F		Felt late at night in Témiscaming. †
19351115	16:11	3.1	OTT	
19351125	06:19	4.3	SHF	Felt in Widdifield Mattawa and North Bay.
19351126	14:20	F		Felt in Témiscaming †
19351127	19:31	4.2	SHF	
19351215	10:15	F		Felt in Témiscaming †
19351215	10:45	F		Felt in Témiscaming 'Crack of Thunder' †
19351220	09:00	F		Felt in Témiscaming †
19351220	21:00	F		Felt in Témiscaming †
19360120	06:00	3.8	SHF SFA	Felt in Témiscaming, Mattawa and North Bay
19360325	01:27	4.0	SHF	Felt in Témiscaming and Mattawa

* Times and magnitudes as computed in this report.

** OTT - Ottawa, Ont. SFA - Seven Falls, Que. SHF - Shawinigan Falls, Que.

† Newly documented aftershock.

F – Felt report from Ontario and Quebec newspapers (see Scrapbook), no instrumental readings.

Table 4

Seismicity Within 50 km of Témiscaming, After March 25, 1936

DATE (yyyymmdd)	TIME (hhmm)	MAGNITUDE (m_N)	ORIGINAL LAT - LONG °N	°W	RELOCATION LAT - LONG °N	°W	VECTOR RELOCATION (km)	(Degrees)
19370728	0017	2.7	46.720	79.080	46.885	79.004	19.2	017
19380412	1855	3.2	46.720	79.080	46.885	79.004	19.2	017
19400105	0034	3.0	46.720	79.080	46.885	79.004	19.2	017
19440308	1250	4.0	46.680	78.780	46.642	78.625	19.1	103
19520426	0459	3.6	47.000	78.500	46.772	78.950	42.5	233
19611101	0341	2.9	46.920	79.090	46.885	79.004	19.0	102
19650915*	1756	3.6	46.720	79.050	46.366	78.980	39.7	172
19751219	1525	3.9	47.000	78.850	46.928	78.866	9.3	192
19820813	0106	4.3	46.670	78.503	46.603	78.695	14.6	239
19830110	2131	3.3	46.820	78.830	46.846	78.879	4.7	308
19831127	0949	2.8	46.800	78.770	46.838	78.798	4.7	333
19850520	1144	1.6	46.850	78.880	46.843	78.927	4.1	236
19861001	0525	1.7	47.000	79.070	47.018	79.056	2.5	025
19870817	0132	3.2	46.874	78.897	46.844	78.894	3.3	176
19880217	1127	2.1	46.671	78.859	46.819	78.816	16.8	011
19351101**	0603	6.2 m_b	46.780	79.070	46.885	79.004	12.7	023
19351102**	1431	4.9	47.230	78.170	46.981	78.513	37.9	223

* The 1965 event relocated 40 km to the southeast, out of the study area.

** The mainshock and the largest immediate aftershock.

Table 5

Unlocated Events Near Eldee (EEO) Ontario.

DATE	TIME	MAGNITUDE	S-P DISTANCE FROM EEO (km.)	POLARITY *
19850522	09:08	<2.0	12	
19860322	10:23	1.9	24	C
19860601	05:38	<2.0	64	D
19870905	15:29	<1.0	16	
19870905	18:23	<1.5	16	D
19870929	20:36	<1.5	21	D

* First arrival polarity: C=Compression, D=Dilatation

Table 6

Focal Mechanism Data for Figure 11.

DATE yy-mm-dd	LAT °N	LONG °W	M		TYPE	PLANES strike	dip	rake	P	T	B
									trend/plunge		
35 11 01	46.885	79.004	6.2	A	T	145	50	080	242	002	151
						340	41	122	05	81	08
				B	T	050	50	090	140	320	230
						230	41	122	05	85	00
82 08 13	46.603	78.689	4.3	A	T	125	46	080	222	316	132
						319	45	100	01	83	07
				B	SS	284	70	-004	241	148	025
						087	86	-160	16	11	70
87 08 17	46.884	78.893	3.2	A	T	117	51	077	216	332	123
						317	41	105	05	79	10
				B	SS	040	85	-009	355	086	191
						131	81	-175	10	03	79
Composite	....	....	.....		T	120	50	084	214	350	124
						309	40	097	05	83	05

A and B represent alternative mechanisms for each earthquake.

T=Thrust and SS=Strike-slip, identify the dominant style of faulting implied.

The second of each pair of planes represents the auxilary plane

TABLE 7

Original entries in the Canadian Earthquake Epicentre File (first line)
and recomended changes (second line) for each event.

DATE		TIME	LAT.	LONG.	MAGNITUDE				
yy	mm dd	hh mm ss	°N	°W	m_b	m_N	M_L	M_s	
1935	11 01	06 03 40	46.78	79.07			6.2		M_L
		36.7	46.885	79.004	6.2				m_b
1935	11 01	17 02 40	46.78	79.07		4.1			m_N
		01 46.6	46.885	79.004		4.2			m_N
1935	11 02	00 42 17	46.78	79.07		4.2			m_N
		25.8	46.885	79.004		4.3			m_N
1935	11 02	13 51 21	46.78	79.07			3.0		M_L
		21.8	46.885	79.004		3.9			m_N
1935	11 02	13 55 42	46.78	79.07			2.7		M_L
		42.8	46.885	79.004		3.6			m_N
1935	11 02	14 31 58	47.230	78.170		4.9			m_N
		54.4	46.981	78.513		4.9			m_N
1935	11 05	10 10 48	46.78	79.07			3.9		M_L
		11 12.6	46.885	79.004		4.1			m_N
New Event									
1935	11 05	14 15 00	46.885	79.004		3.0*			m_N
1935	11 07	16 47 04	46.78	79.07			2.4		M_L
		04.8	46.885	79.004		3.9*			m_N
New Event									
1935	11 07	?? ?? ??	46.885	79.004		3.0*			m_N
1935	11 15	16 11 20	46.78	79.07			3.0		M_L
			46.885	79.004		3.9			m_N

TABLE 7

DATE		TIME	LAT.	LONG.	MAGNITUDE				
yy	mm dd	hh mm ss	°N	°W	m_b	m_N	M_L	M_s	
1935	11 25	06 19 19	46.78	79.07		4.1			m_N
		24.6	46.885	79.004		4.1			m_N
New Event									
1935	11 26	14 20 00	46.885	79.004		3.0*			m_N
1935	11 27	19 31 49	46.78	79.07			4.1		M_L
		54.8	46.885	79.004		4.3			m_N
1935	12 15	10 15	46.78	79.07			3.0		M_L
			46.885	79.004		3.0*			m_N
New Event									
1935	12 15	10 40 43.6	46.885	79.004		4.2			m_N
New Event									
1935	12 20	09 00	46.885	79.004		3.0*			m_N
New Event									
1935	12 20	21 00	46.885	79.004		3.0*			m_N
1936	01 20	06 01	46.78	79.07		3.8			m_N
		00 09.5	46.885	79.004		4.2			m_N
1936	03 25	01 27 25	46.78	79.07		4.0			m_N
		30.8	46.885	79.004		4.1			m_N
1937	07 28	00 17	46.72	79.08			2.7		M_L
		00.8	46.885	79.004		3.0*			m_N
1938	04 12	18 55 47	46.72	79.08			3.2		M_L
		48.8	46.885	79.004		3.0			m_N
1940	01 05	00 34 14	46.72	79.08			3.0		M_L
		08.8	46.885	79.004		3.0			m_N
1944	03 08	12 49 56.1	46.68	78.87			4.1		M_L
		50 02.0	46.642	78.625		4.0			m_N

TABLE 7

DATE		TIME	LAT.	LONG.	MAGNITUDE				
yy	mm dd	hh mm ss	°N	°W	m_b	m_N	M_L	M_s	
1952	04 26	04 59 44.4	47.0	78.5			3.7		M_L
		42.0	46.772	78.950		3.6			m_N
1961	11 01	03 41 21	46.92	79.09			2.9		M_L
		24.8	46.885	79.004		2.9			m_N
1965	09 15	17 56 28	46.72	79.05			3.8		M_L
		33.1	46.366	78.980		3.6			m_N
1975	12 19	15 25 11	47.00	78.85		3.8			m_N
		11.4	46.928	78.866		3.9			m_N
1982	08 13	01 06 40	46.67	78.53		4.3			m_N
		39.9	46.603	78.695		4.3			m_N
1983	01 10	21 31 27	46.82	78.83		3.3			m_N
		25.8	46.846	78.879		3.3			m_N
1983	11 27	09 49 24	46.80	78.77		2.8			m_N
		22.9	46.838	78.798		2.8			m_N
1985	05 20	11 44 39	46.85	78.88		1.6			m_N
		39.6	46.843	78.927		1.6			m_N
1986	10 01	05 25 04.0	47.000	79.070		1.7			m_N
		04.5	47.018	79.057		1.7			m_N
1987	08 17	01 32 10.1	46.874	78.897		3.2			m_N
		10.6	46.844	78.894		3.2			m_N
New Event									
1987	09 29	20 36 06.8	46.578	78.838		1.8			m_N
1988	02 17	11 27 54.7	46.671	78.859		2.1			m_N
		53.5	46.819	78.816		2.1			m_N

Notes - Depths pegged at 10 km for all events (as for mainshock). Probable depth 10 ± 10 km.

* All felt earthquakes without instrumental data are assigned magnitudes of m_N=3.0

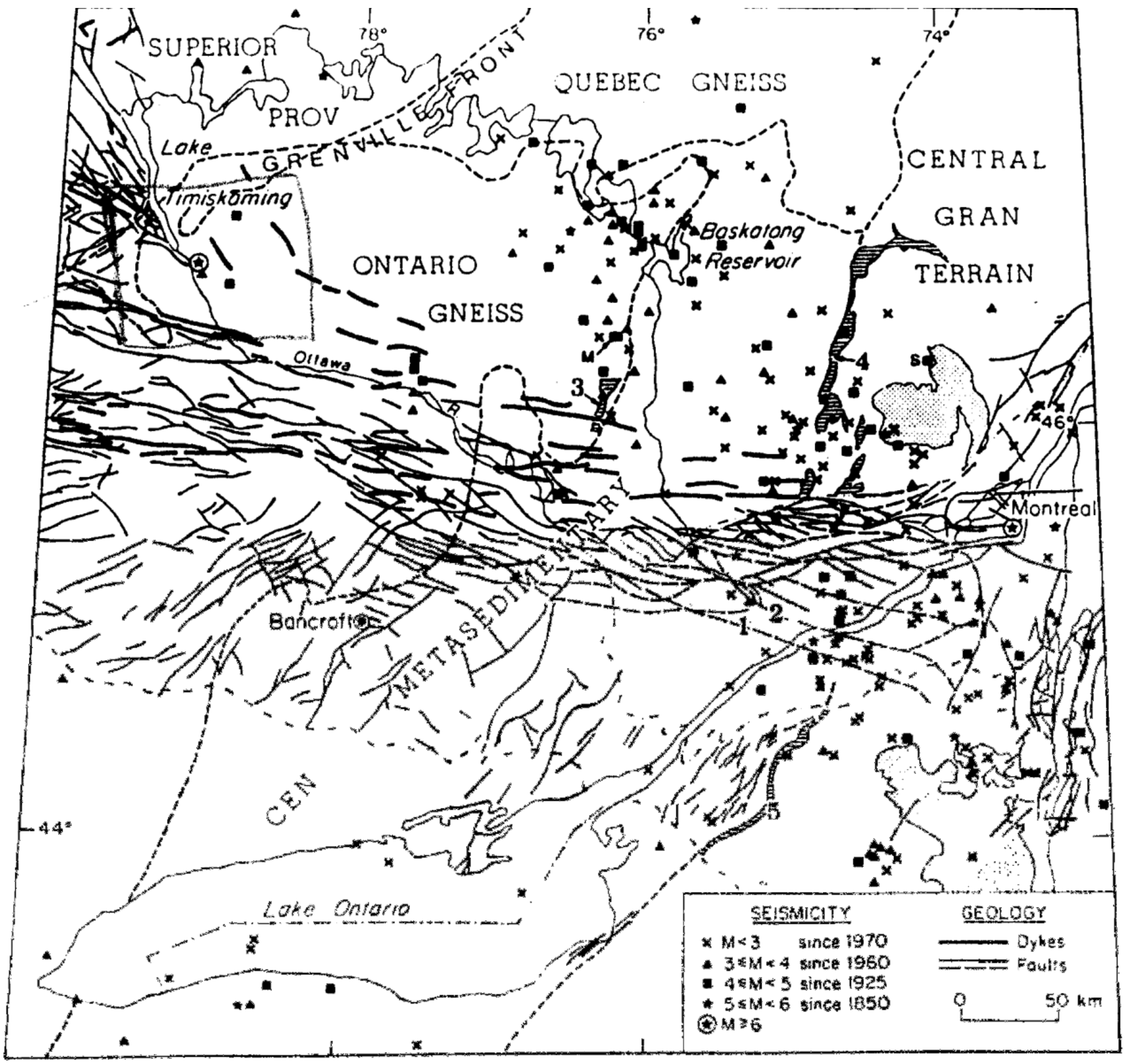

Figure 1. Seismicity and geologic features in and near the Western Quebec Seismic Zone. Dashed lines indicate the northeastern limit of Paleozoic cover, while short dashes indicate geological province subdivisions in the basement (from Forsyth, 1981, Fig 1.)

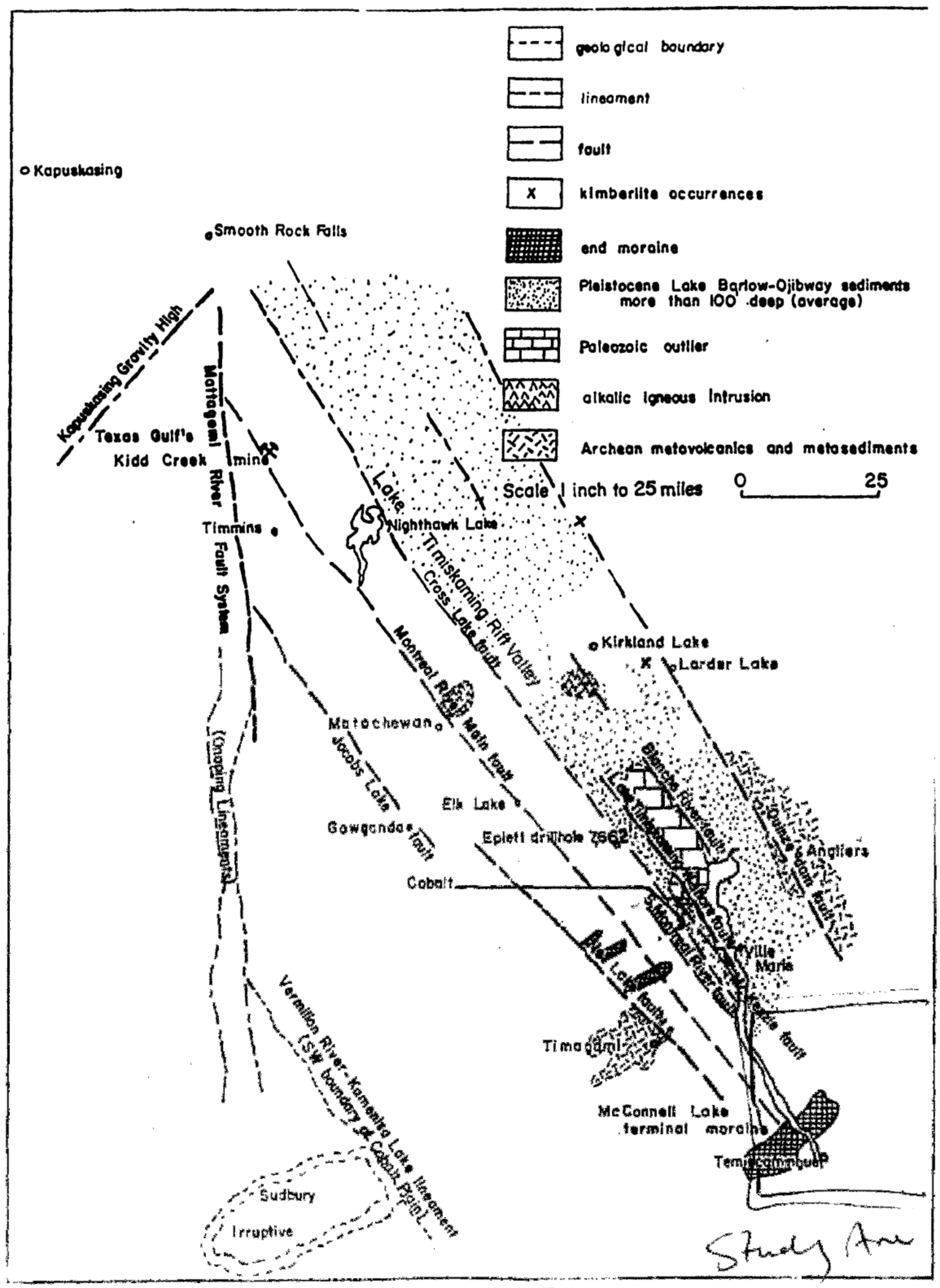

Figure 2. Lake Timiskaming Rift Valley and associated structures according to Lovell and Caine (1970). The Kipawa Seismic Zone lies in the extreme bottom-right corner.

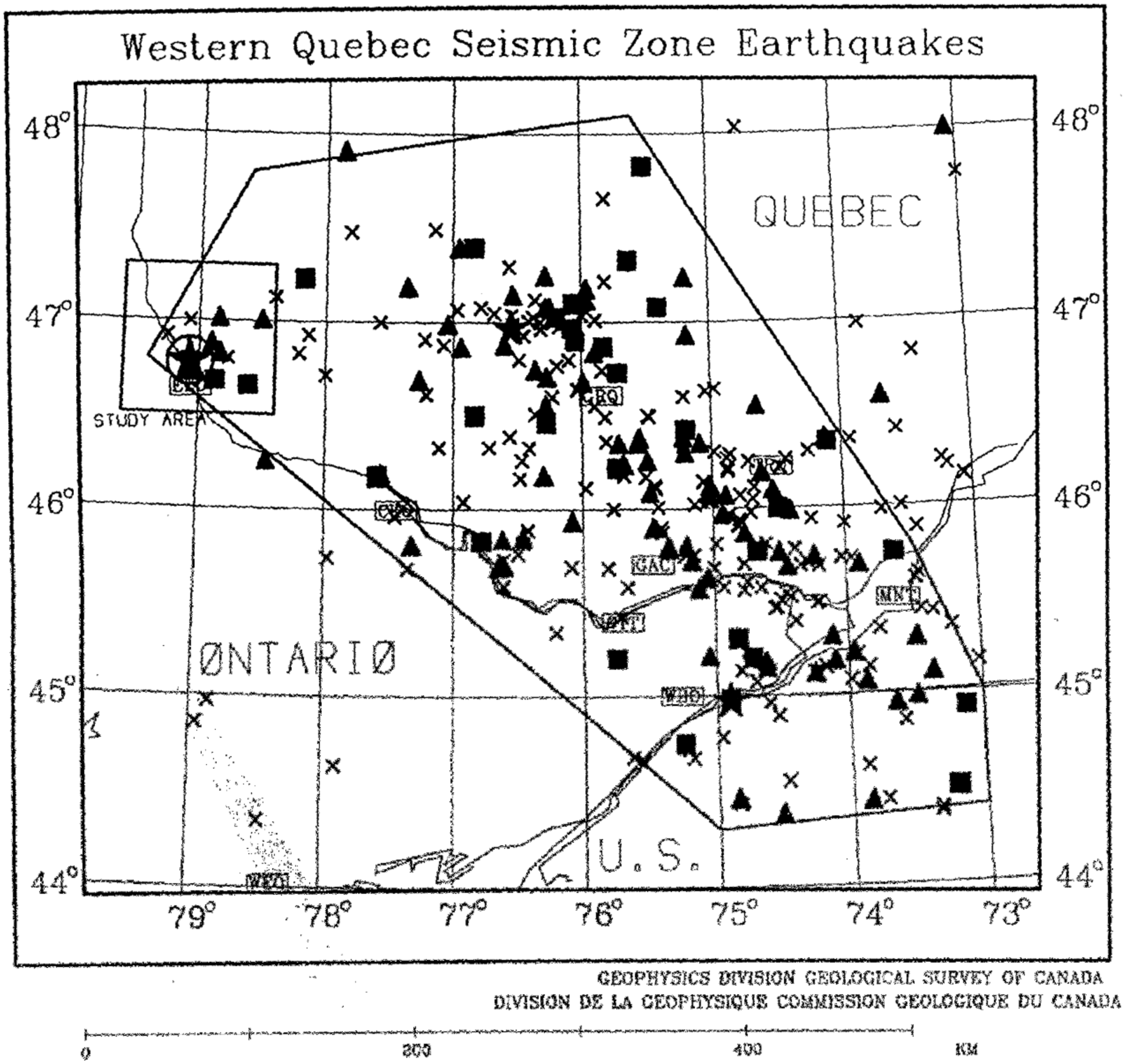

Figure 3. The Western Quebec Seismic Zone together with a suite of earthquakes chosen based on the improving detection ability of the seismic network: M=6.0 since 1900, M=5.0 since 1928, M=4.0 since 1937, M=3.0 since 1968, and M=2.0 since 1980. OTT, GAC, etc. represent seismometers, and the study area of this report is boxed.

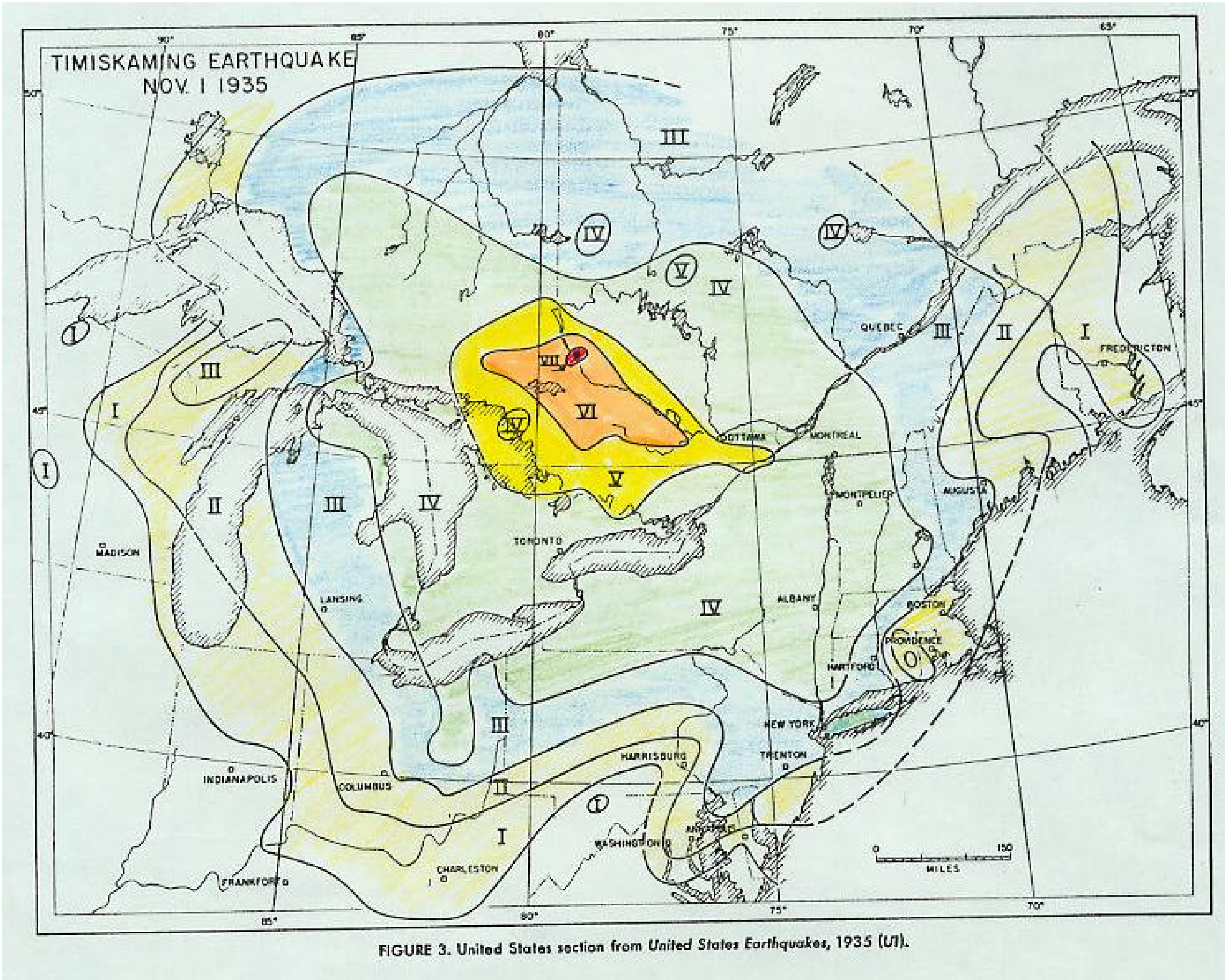

Figure 4. Isoseismal map of the Timiskaming Earthquake (from Smith, 1966). Maximum felt intensity was Modified Mercalli Scale VII (see Appendix A for felt reports).

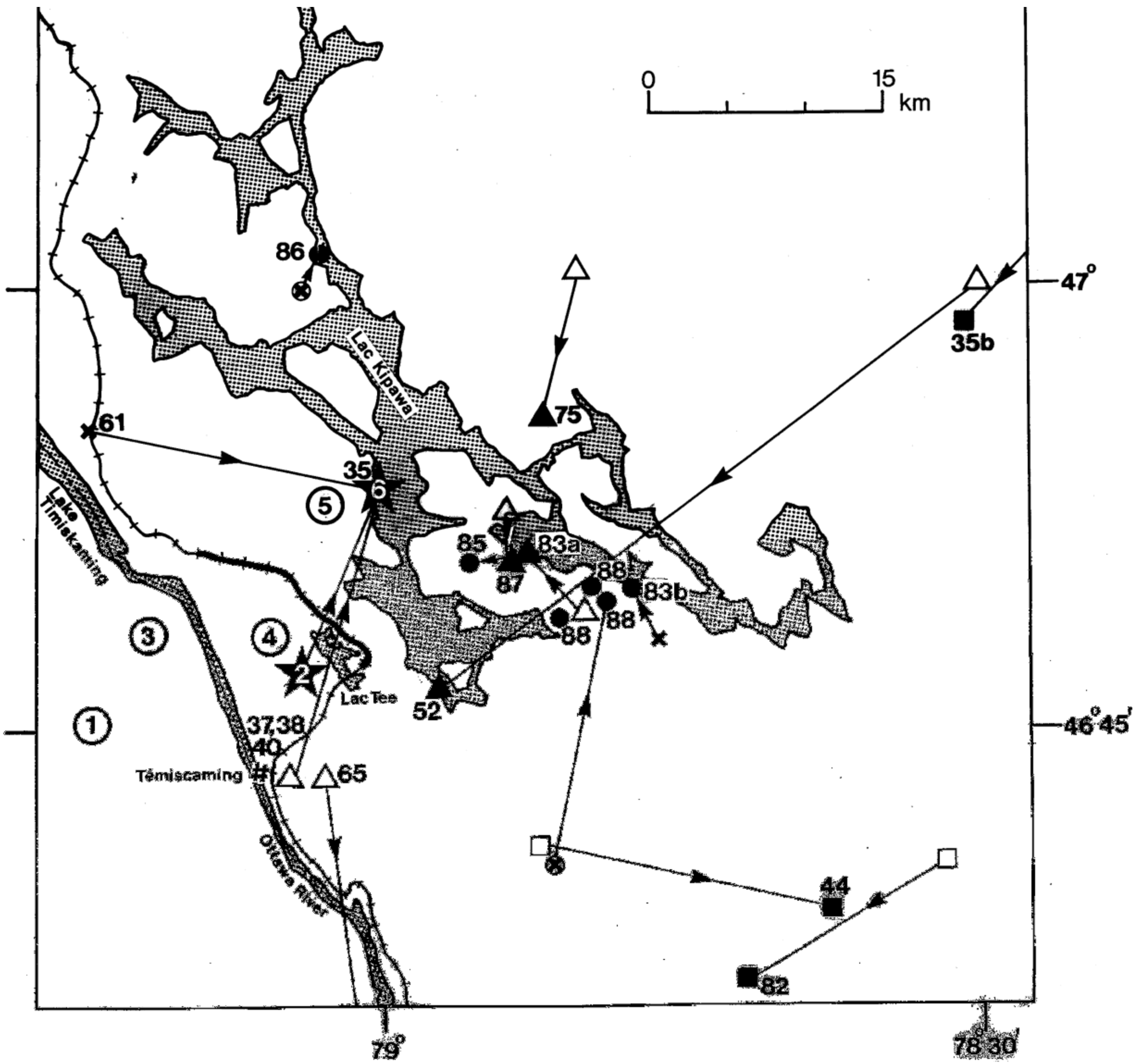

Figure 5. Revisions to the seismicity of the Kipawa Seismic Zone. Epicentres determined for the Timiskaming mainshock (see Table 1) are:— 1: Hodgson 1936a; 2: Hodgson 1936b; 3: ISS; 4: Gutenberg and Richter (1949); 5: Dewey and Gordon (1984); 6: This Report (1988). Sections of the railway that shifted during the mainshock are shown by a heavier line. For subsequent earthquakes a vector joins the old (open symbol) to the revised (filled symbol) location, and the symbols indicate magnitude as on Fig. 3. Note the largest aftershock recorded on 2nd November at 14:31 moves southwest into the map area near its eastern edge and the 1965 earthquake moves off the map to the southeast.

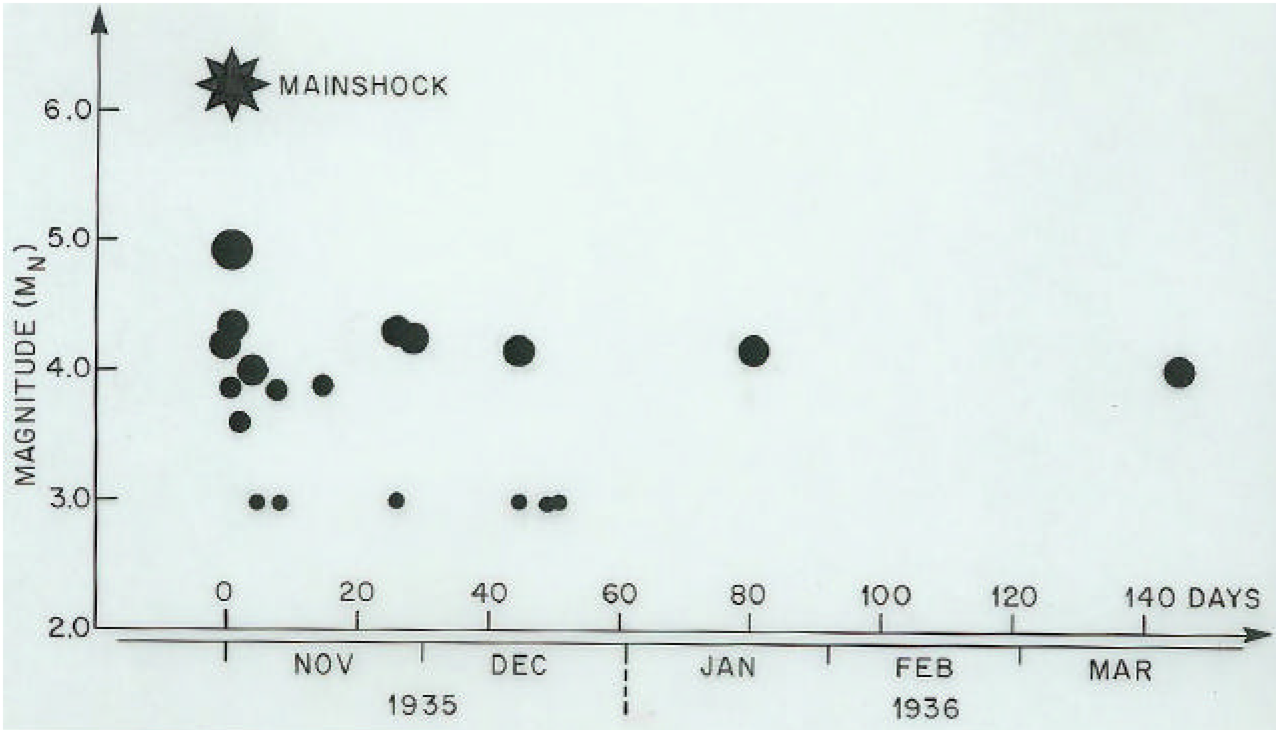

Figure 6. Aftershocks of the Timiskaming Earthquake, 1 November 1935, displayed by plotting magnitude against time since the mainshock.

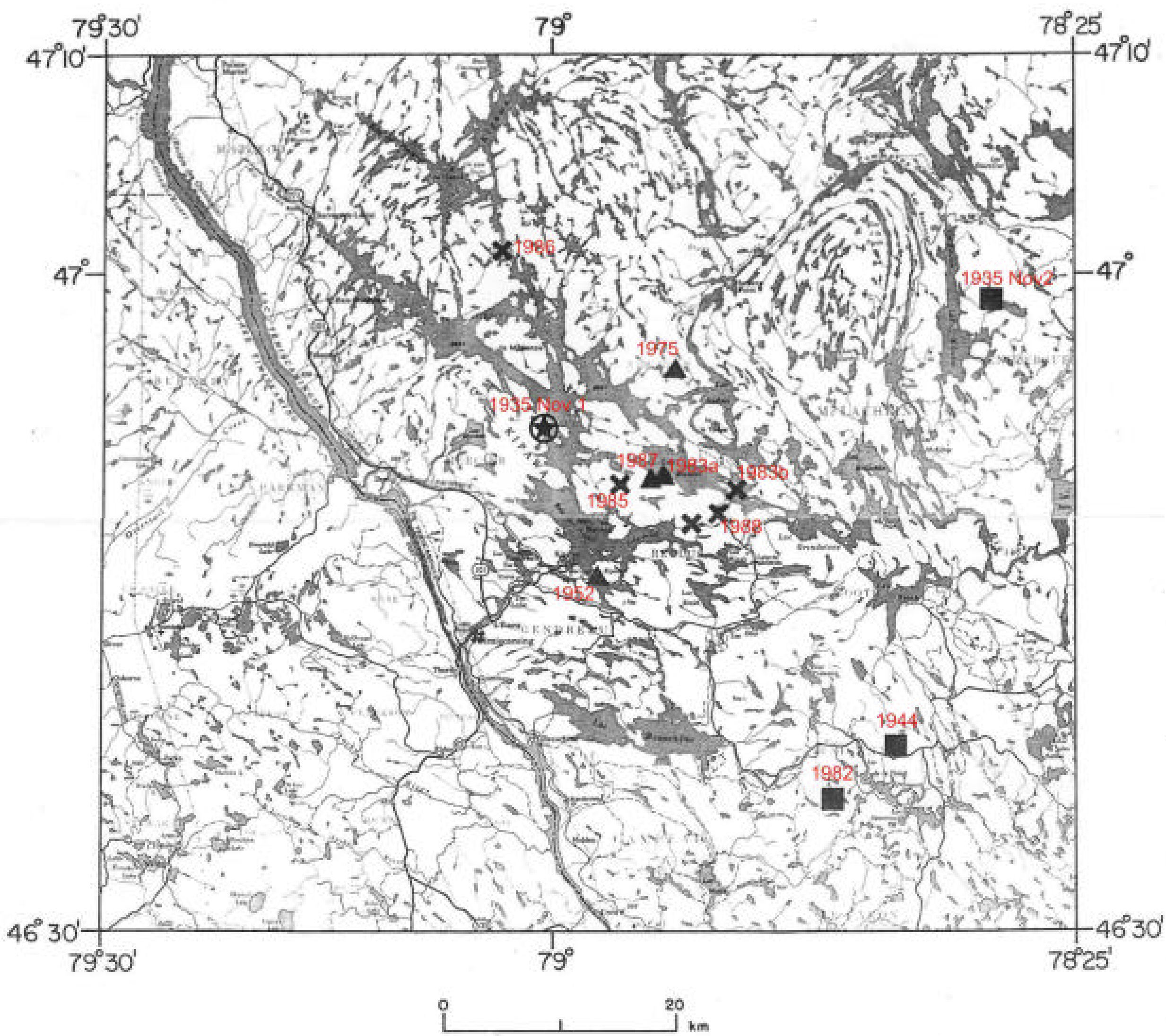

Figure 7. Revised seismicity of the Kipawa Seismic Zone superimposed on a topographic map base. Symbols as on Fig. 3.

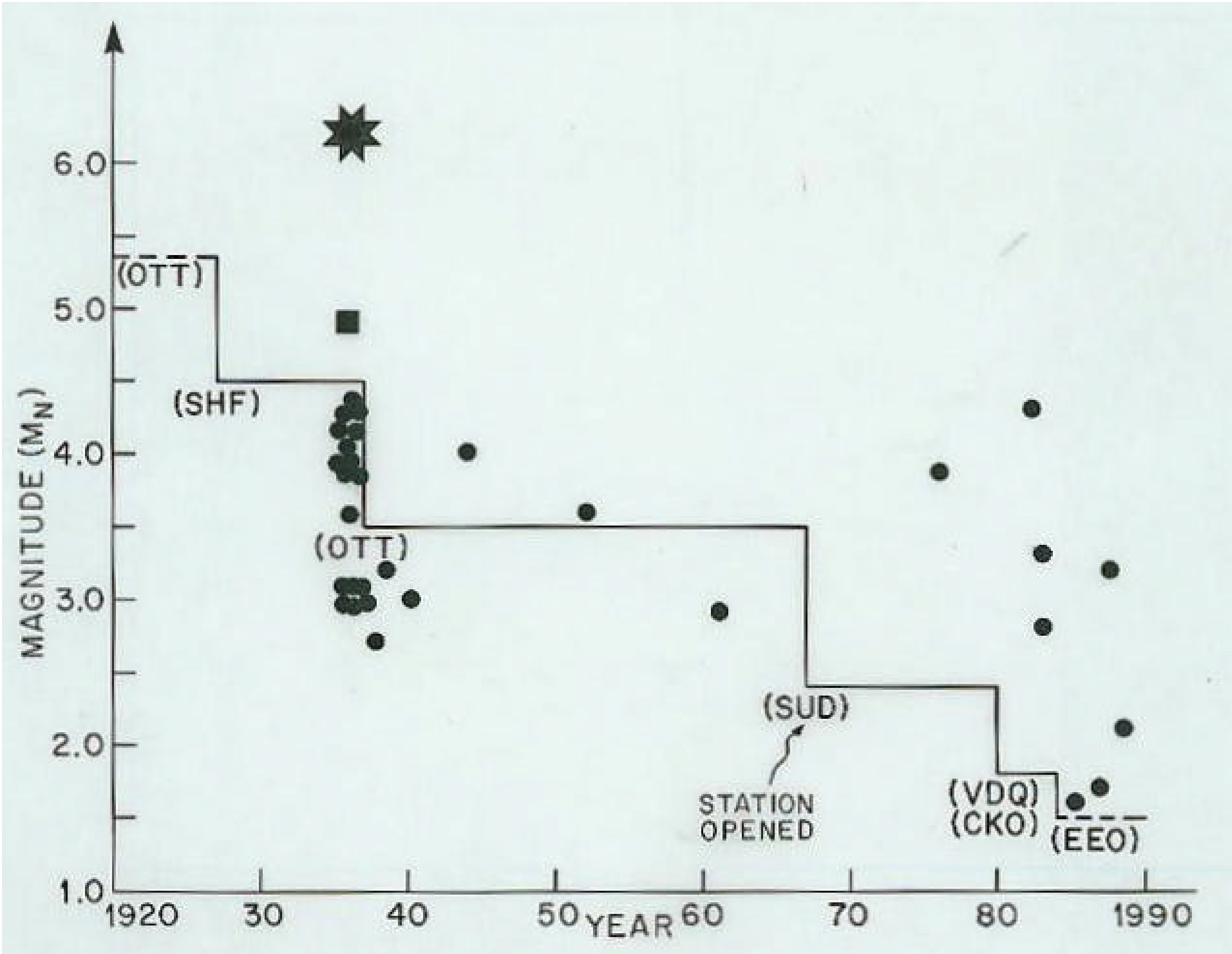

Figure 8. Earthquakes in the Kipawa Seismic Zone, displayed by plotting magnitude against date. The down-stepping line represents the magnitude detection threshold determined in Appendix C and is labeled with the most sensitive station at each time (e.g. SUD).

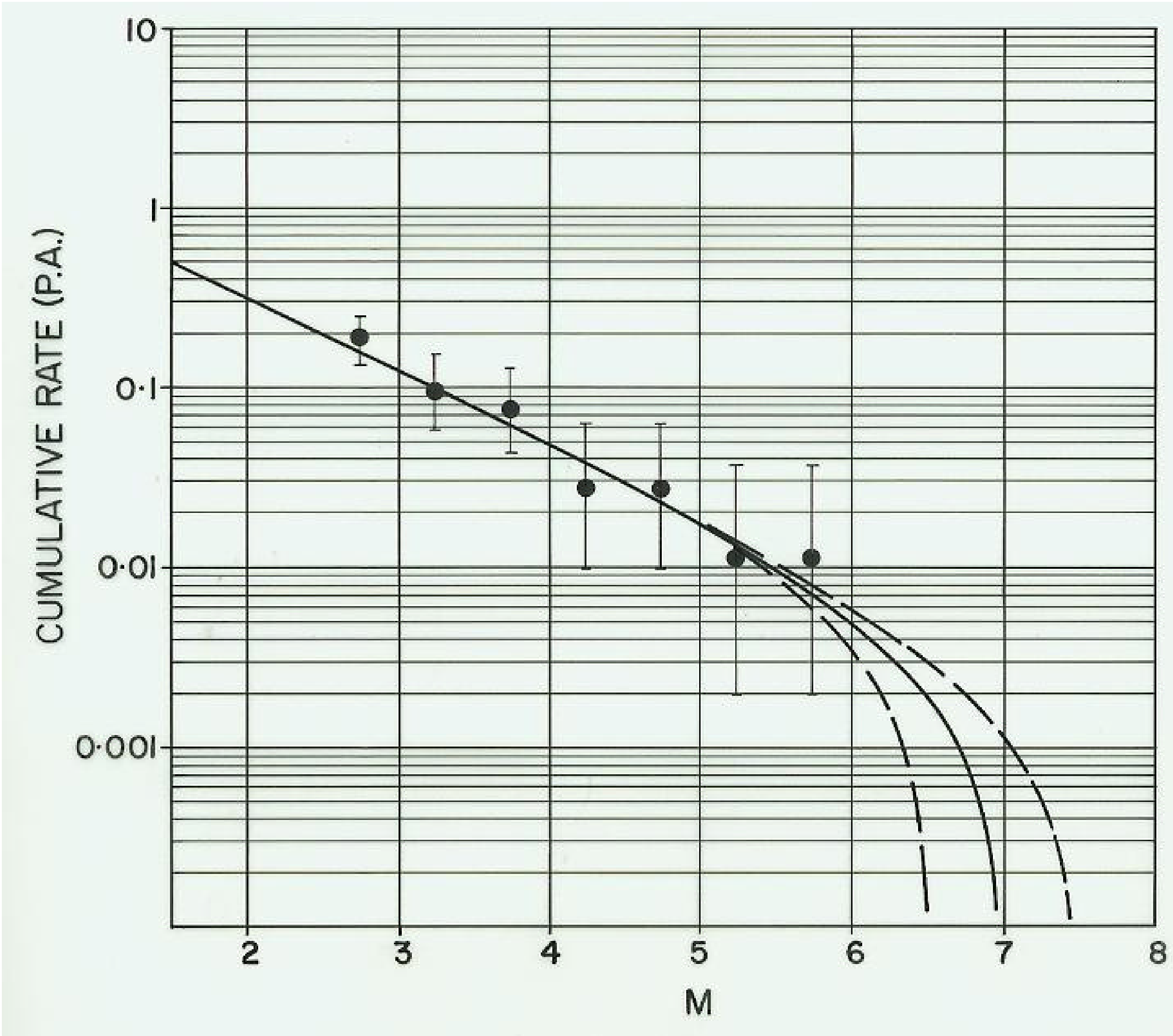

Figure 9. Rate of seismicity in the Kipawa Seismic Zone shown as a cumulative plot of rate against magnitude. The maximum magnitude (Mx is taken to be 7.0, but the derived curves for 6.5 and 7.5 are shown dotted (see Appendix D).

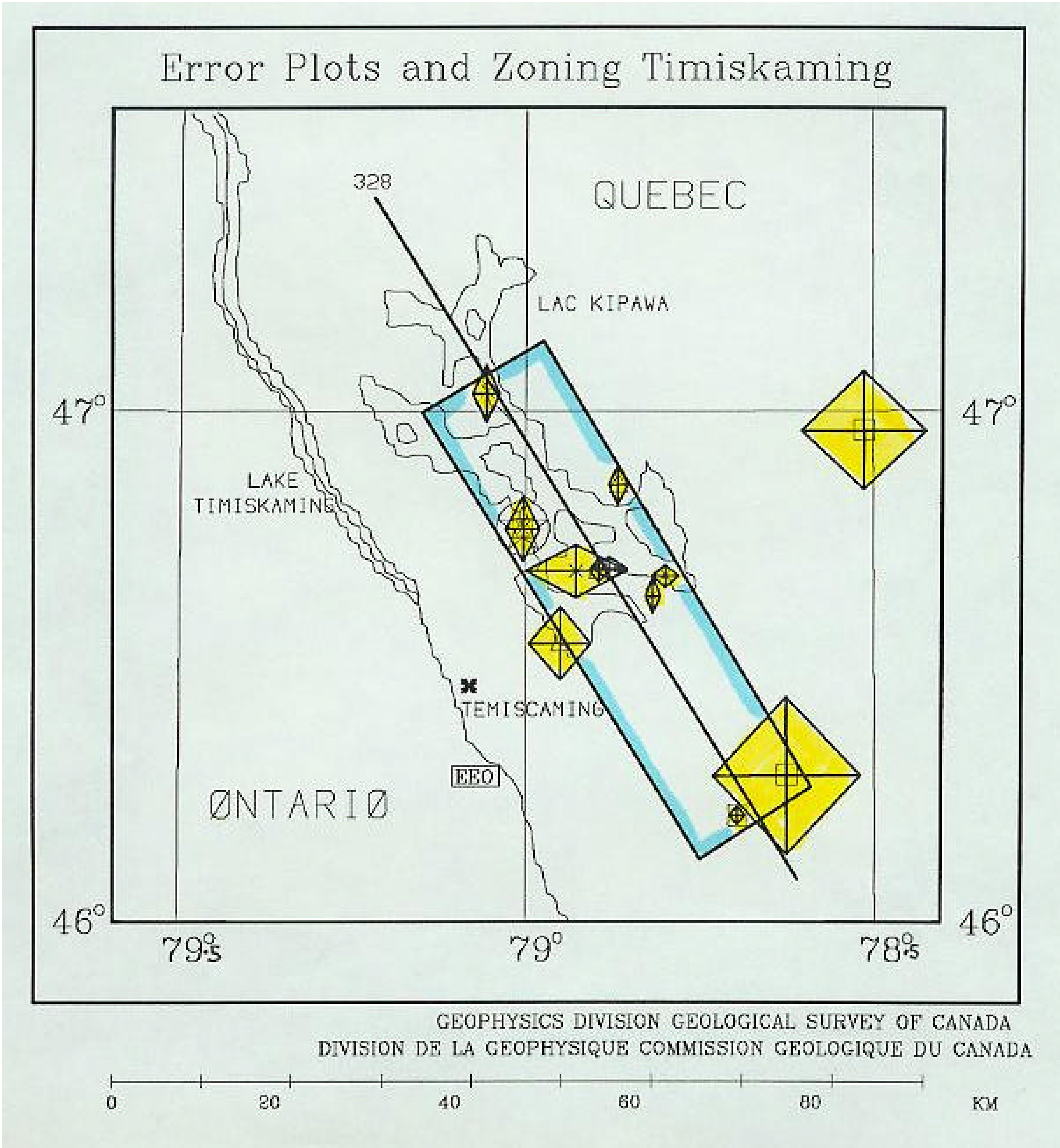

Figure 10. Revised epicentres, errors and suggested boundaries for the Kipawa Seismic Zone. The error associated with each epicentre is shown as a diamond. The northwest-trending (328°) rectangle is suggested for the limits of the Kipawa Seismic Zone.

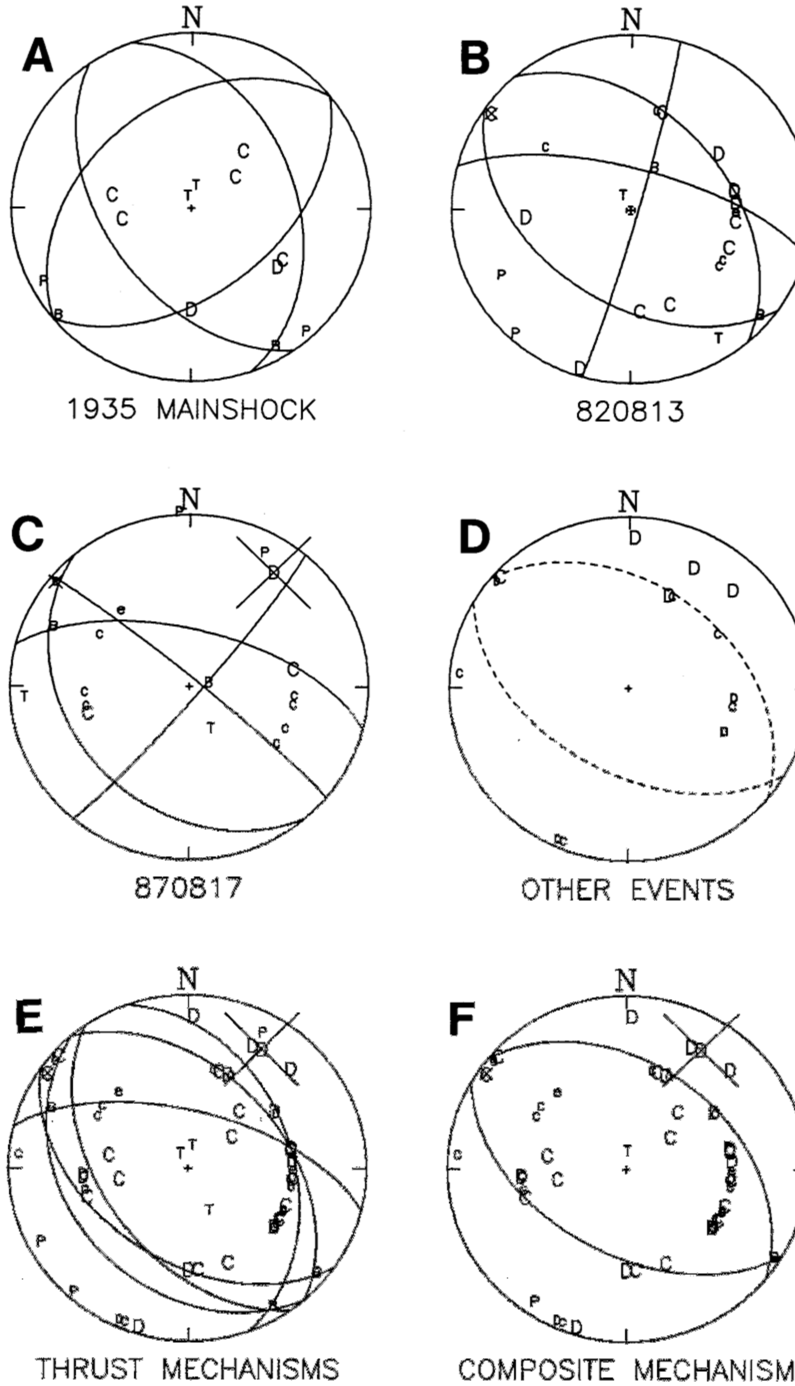

Figure 11. Focal mechanism solutions (lower hemisphere stereonets) for Kipawa earthquakes. Compressional first motion polarities are designated as C, dilatational first motions are D (half-weight, small C and D), and S/P amplitude ratios are represented as various sized X's centered on the polarity. Pressure (P) Tension (T) and B axis are also plotted. **A:** mainshock solutions of Ebel et al. (1986). **B** and **C:** solutions for the 1982 and 1987 earthquakes. **D:** combined polarities from other earthquakes in the KSZ. The dashed line shows the best solution of F. **E:** thrust mechanisms from A,B and C, together with all polarity data. **F:** best composite focal mechanism solution for all the data.

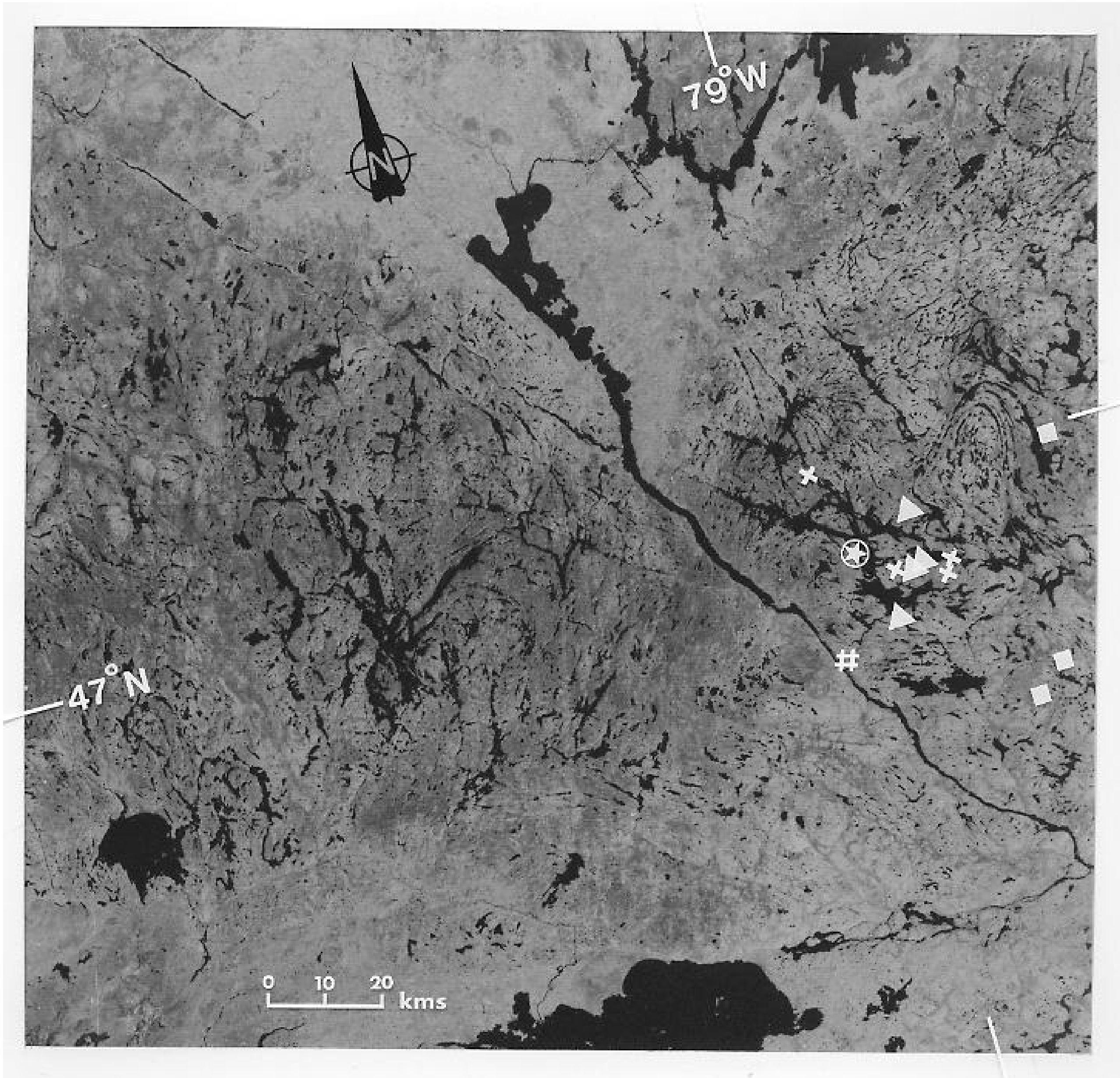

Figure 12. Revised KSZ earthquakes superimposed on LANDSAT photograph. Note the intersection of the northwest– and north-northwest–trending lineaments at Lac Kipawa.

APPENDIX A

Summary of Felt Reports for Timiskaming Mainshock

(After Hodgson (1936b), and the Dominion Observatory Scrapbook)

Felt over an area between 500,000 and 800,000 square miles (~1.3 million km^2) - no casualties.

From Hodgson (1936b)

Témiscaming

- 80% of chimneys damaged to some extent
- some cracks in solid brick walls
- one ten-inch water pipe broken (was not strong to begin with)
- some heavy objects shifted toward the NNE
- man on tower 160 ft. above ground noticed a violent swaying of the tower to the north, then an east-west movement
- cracks appeared in sand/gravel or relatively high relief areas around Témiscaming

Lac Tee (just to the southwest of Lac Kipawa)

- clear waters up to night of earthquake, November 2 water discoloured to a milky coffee colour, caused by underwater slumps documented by Shilts (1984) that were triggered by the earthquake. (epicentre near this lake)

Lac Kipawa

- gravelly and rocky shores disturbed, with some discolouration of lake.
- rock fall, 200 ft.
- log cabin lodge shifted bodily to the WSW

Parent,Que

- earthquake triggered sand slide (190 miles) from epicenter; 100 ft. of railway right of way slipped into a lake.

From Newspaper Clippings in Scrapbook

Pembroke

- two chimneys collapsed, many cracked walls.

Renfrew

- some chimneys collapsed.

Kingston

- chimney collapsed causing house to burn to ground.

Ottawa

- 6 chimneys destroyed, many cracked walls, telephone lines disrupted.
- At Observatory 3 out of 5 seismographs put out of commission.

Toronto

- kitchen ceiling collapsed, two chimneys collapsed, water and gas mains broken.

Hamilton

- telephone lines disrupted, woman fell down stairs (not hurt).

Simcoe

some cracked walls.

Mattawa

telephone poles fell, collapsed embankments.

Richmond

cracked foundations and damaged chimneys.

Uno Park (North of Haileybury)

artesian wells reported increased yield after shock; water was muddy for a few days after shock, then cleared.

General (Hodgson 1936b, newspaper clippings)

- no rock movement seen greater than 20 miles from epicentre
- rails in the Kipawa-Dozois section of C.P.R. shifted
- miners throughout central Ontario and Quebec did not feel quake within the mines but it was felt on surface.
- thousands of residents in many cities fled into the streets.
- loose objects shaken severely and sometimes damaged.
- broken windows in many centres close to epicentre.
- people reported `thrown' out of bed in Montreal, St. Thomas, North Bay. (usually in upper floors of multi-story buildings)

Reported severe shaking with no damage

Cornwall, Morrisburg, Burbridge,Winchester, Chesterville, Prescott, Rockland, Timmins, Montreal, Sherbrooke, Saint John, Owen Sound, Quebec city, St. Thomas, Windsor, North Bay, Sudbury, Hawksbury, Alexandria, Maxville, Ste Anne de Bellevue, Hanover, Kincardine, Smith Falls, Carlton Place, Doucet, Amos, Rouyn-Noranda, upper New York State.

Other Felt reports

Winnipeg, Halifax, many small towns in Ontario, Quebec and the Maritimes (isolated reports)

Border of felt area

West to Fort William, Ontario ; east to the Bay of Fundy north to the Arctic ?? ; south to Virginia

American reports

Felt in 17 states -- Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Ohio, West Virginia, Indiana, Michigan, Illinois, Wisconsin.

telephone service disrupted in upper New York State.

house reported to have collapsed in Syracuse, New York.

APPENDIX B Earthquake Solutions

```
+46.885- 79.004F MN=6.2 0603367 01111935 00.0320.025 0.0 16 23  00.92 210.00   0 1ML=0.0  00  0 3.65
$ NOVEMBER 1 1935, EVENT AT 06:03 U.T. ; TIMISKAMING EARTHQUAKE.
$46.8  - 79.2                ?          (ISS)
$46 47'- 79 04'           DEPTH 200 KM.  (HODGSON, 1936)
$46 35'- 79 04'           DEPTH NORMAL   (HODGSON, 1937)
$46.8  - 79.1             DEPTH 60 KM    (GUTTENBERG AND RICHTER,1949)
$46.874- 79.051     FIXED DEPTH  1 KM    (DEWEY AND GORDON, 1984)
$46.9  - 79.1             DEPTH 10 KM    (EBEL ET AL, 1986)(EPICENTRE FROM
$                                           DEWEY AND GORDON - ROUNDED UP)
$-------------------------------------------------------------------------------
$ MAGNITUDE CALCULATI0NS                                  SEISMIC MOMENT
$ ----------------------                                  --------------
$     MB =  6.1     (EBEL ET AL, 1986)                  5 X 10 E25 DYN.CM
$     MB =  6.3     (STREET AND TURCOTTE, 1977)       (SURFACE WAVE MOMENT)
$     ML = >5.5     (EBEL 1982)                         (EBEL ET AL, 1986)
$     MS =  6.25    (GUTENBURG AND RICHTER, 1954)
$        =  6.1     (STREET AND TURCOTTE, 1977)
$        =  6.0     (EBEL ET AL, 1986)
$
$  MAXIMUM MMI INTENSITY OF VII NEAR EPICENTRE (SMITH, 1966)
$-------------------------------------------------------------------------------
$ AFTERSHOCKS - 19 RECORDED IN NEWSPAPERS, 12 PRESENTLY IN CEEF FILE.
$-------------------------------------------------------------------------------
$ SOLUTION  - BASED ON LOCAL PHASES
$ --------
$   VALUES USED ARE FROM THE INTERNATIONAL SEISMOLOGICAL SUMMARY, 1935 (ISS)
$    AND DOMINION OBSERVATORY RECORDS (OTTAWA)
$ SAS - 8 SEC. TIME CORRECTION ARBITRARILY ADDED, PN AND SN WERE BOTH
$       OFF BY -8 SEC.
$ PHI - SN VALUE PROBABLY LG (SN RESIDUAL 38+ SEC)(CONFIRMED BY (LEHMANN,1955))
$ ORT - STATED VALUE PROBABLY OFF BY ONE MINUTE, RESIDUALS AT PN 0516
$       (ISS) ARE VERY HIGH UNLESS ONE MINUTE WAS ADDED
$     - LARGE PN RESIDUAL NOT USED IN CALCULATION
$ TNT - READING WITH HIGH PN RESIDUAL IS EAST COMPONENT, LOW PN RESIDUAL
$       BUT HIGHER SN IS NORTH COMPONENT. LEHMANN ,1955 BELIEVED THAT
$       EAST COMPONENT READING WAS IN ERROR FOR PN ARRIVAL.
$ BUF - READINGS READ OFF COPIES OF ORIGINAL RECORDS.
```

```
$ LRA - POSSIBLE TIMING ERROR
$ SHF - NO RECORDING OF PHASES FOUND, ORIGIN TIME = 6-04+1-00V (QUEBEC STATION
$ SFA - "      "     "    "      "      "     "   = 6-05+0-33V    REPORTS)
OTT  3511010603P  A0420                        B0453
OTT   SE 0303KM 31 -030 122 49                 08  098           0000000 00ML00MN
TNT  3511010603P  B0426                       XB0501
TNT   S  0359KM 08 -110 185 49                 00 -289           0000000 00ML00MN
TNT  3511010603P  X0422                        B0503
TNT   S  0359KM 00 -510 185 49                 08 -089           0000000 00ML00MN
BUF  3511010603P  B0437D                      XB0525
BUF   S  0440KM 08  009 178 49                 00  400           0000000 00ML00MN
INY  3511010603P  B0448                        B0540
INY   SE 0533KM 08 -027 157 49                 08 -082           0000000 00ML00MN
AAM  3511010603P  B0500
AAM   SW 0629KM 08 -007 218 49                                   0000000 00ML00MN
WES  3511010603P  B0519
WES   SE 0788KM 08 -042 127 49                                   0000000 00ML00MN
PHI  3511010603P  B0524                               XB0719
PHI   SE 0815KM 08  136 156 49                         00 -095   0000000 00ML00MN
CHI  3511010603P  B0531                        X0646
CHI   SW 0882KM 08  007 234 49                 00 -924           0000000 00ML00MN
MDS  3511010603P  B0539                        X0713
MDS   W  0931KM 08  210 249 49                 00  734           0000000 00ML00MN
CVL  3511010603P  B0543                        B0720
CVL   S  0990KM 08 -109 177 49                 08  180           0000000 00ML00MN
HAL  3511010603P  B0614                        B0810
HAL   E  1223KM 08  151 096 49                 08  225           0000000 00ML00MN
FLO  3511010603P  B0619                        B0823
FLO   SW 1290KM 08 -165 230 49                 08  101           0000000 00ML00MN
SLM  3511010603P  B0620                        B0825
SLM   SW 1296KM 08 -137 229 49                 08  175           0000000 00ML00MN
ORT  3511010603P  X0616
ORT   S  1297KM 00 -546 202 49                                   0000000 00ML00MN
DMI  3511010603P  X0640                        B0826
DMI   W  1309KM 00 1701$249 49                 08 -006           0000000 00ML00MN
LRA  3511010603P  X0740                        X1034
LRA   SW 1749KM 00 2339$225 49                 00 3438$          0000000 00ML00MN
SAS  3511010603P  B0745      8.0               B1100
SAS   NW 2072KM 08  001 297 45                 08 -036           0000000 00ML00MN
             Z
```

```
+46.885- 79.004O MN=4.2 1701466 01111935 00.0000.000 0.0  1  2  10.00H210.00   0 1ML=4.7  10  0 3.65
$ NOVEMBER 1 1935, EVENT AT 17:01  - TIMISKAMING AFTERSHOCK
$ ONLY ONE STATION RECORDED THIS EVENT, READINGS WERE TAKEN AS SN AND SG.(1935)
$  A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$   CALCULATED MAGNITUDE IN 1935 OF ML=4.6 - ORIGIN TIME IN 1935 OF 17:02:40.
$  NEW ORIGIN TIME CALCULATED AT 17:01:46
$  NOTE THAT IF PN AND PG WERE USED, THE NEW ORIGIN TIME WOULD FIT THE 1935
4   ORIGIN TIME.
SHF  3511011704P                            B0340   B0357    60 1.8   8
SHF   E  0479KM         092 49              10  081 10 -081   0004654 47ML42MN
             Z

+46.885- 79.004O MN=4.3 0042258 02111935 00.0000.000 0.1  2  3  20.00H210.00   0 1ML=4.9  10  0 3.65
$ NOVEMBER 2 1935, EVENT AT 00:42  - TIMISKAMING AFTERSHOCK
$ FELT IN TIMISKAMING
$ SMITH HAD ONLY SHF READINGS; ADAMS ADDED SFA ON 881007
$ OTT RECORD MISSING
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    CALCULATED MAGNITUDE IN 1935 OF ML=4.7.
SHF  3511020044P                            B4417   B4434    60 1.8  12
SHF   E  0479KM         092 49              10 -143 10 -305   0006981 49ML44MN
SFA  3511020044P                           XB4455   B4515    50 1.8  04
SFA   E  0623KM         085 49              00  593 10 -146   0002793 49ML42MN
             Z

+46.885- 79.004O MN=3.9 1351218 02111935 00.0000.000 0.0  1  1  10.00H210.00   0 1ML=4.1  10  0 3.65
$ NOVEMBER 2 1935, EVENT AT 13:51  - TIMISKAMING AFTERSHOCK
$ ONLY OTT RECORDED THIS EVENT AND ONLY ONE PHASE WAS RECORDED.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    ESTIMATED MAGNITUDE IN 1935 OF ML=3.0.
$ SMITH'S CARD HAS A COPY OF THE ORIGINAL OTT RECORD, PROBABLY MADE FROM
$   MICROFILM, THAT IS 2/3 SIZE OF ORIGINALS
$   AMPLITUDE/PERIOD READINGS OF RECORD (1988) ARE .2 MM AT 0.9 SEC.
$ NOT ON SHF, SFA ORIGINAL RECORDS (ADAMS, OCT 1988)
OTT  3511021353P                                    B5245    90 0.3   2
OTT   SE 0303KM         122 49                      10  000   0004654 41ML39MN
             Z
```

```
+46.885- 79.004O MN=3.6 1355428 02111935 00.0000.000 0.0  1  1  10.00H210.00   0 1ML=3.8  10  0 3.65
$ NOVEMBER 2 1935, EVENT AT 13:55  - TIMISKAMING AFTERSHOCK
$ ONLY OTT RECORDED THIS EVENT, READING WAS TAKEN AS SN IN 1935.
$    WITH AN ORIGIN TIME OF 13:55:42.
$ A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK
$    CALCULATED MAGNITUDE IN 1935 OF ML=2.7,
$ SMITH'S CARD HAS A COPY OF THE ORIGINAL OTT RECORD, PROBABLY MADE FROM
$   MICROFILM, THAT IS 2/3 SIZE OF ORIGINAL
$ NOT ON SHF, SFA ORIGINAL RECORDS (DAMS, OCT 1988)
$   AMPLITUDE/PERIOD READINGS OF OTT RECORD (1988) ARE .1 MM AT 0.9 SEC.
OTT  3511021357P                                    B5706    90 0.3   1
OTT   SE 0303KM         122 49                      10  000   0002327 38ML36MN
             Z

+46.981- 78.513F MN=4.9 1431544 02111935 00.0580.090 0.2  4 10  31.11 210.00   0 1ML=5.3  30  0 3.65
$ NOVEMBER 2 1935, EVENT AT 14:31  - DISPLACED TIMISKAMING AFTERSHOCK
$ 47.230 N 78.170 W LOCATION GIVEN BY DOMINION OBSERVATORY RECORDS.
$ 46.885 N 79.004 W MAINSHOCK EPICENTER.
$ 46.8   N 79.2   W ISS LOCATION.
$ REPORTED FELT IN ONTARIO AS FAR AWAY AS - KITCHENER,NORTH BAY, OWEN
$   SOUND, AND TORONTO.
$ REPORTED FELT IN U.S. - BUFFALO, ROCHESTER AND STATE COLLEGE IN
$   PENNSYLVANIA.
$ CALCULATED MAGNITUDE IN 1935 OF ML=5.4
$ OTT - SN REREAD OFF OF ORIGINAL RECORDS AS 3305 NOT 3307
$ ORT - ISS READINGS GIVE 2.5 MINUTE RESIDUALS THEREFORE NOT USED
$ TNT - PN ARRIVAL TIME EARLIER THAN THAT OF OTT THEREFORE NOT USED. SN READING
$      GIVES A HIGH RESIDUAL, WHEN USED AS PG VALUE RESIDUAL ONLY 16 SEC. THIS
$      VALUE IS STILL TOO HIGH TO USE IN CALCULATIONS.
$ LRA - SN,SG  RESIDUALS TO0 HIGH THEREFORE VALUE NOT USED IN CALCULATION,
$      POSSIBLE TIMING ERROR WITH BOTH OFF BY 14 SEC.  SN-3838   SG-4018
$ INY - PHASE DOES NOT FIT EITHER SN OR SG THEREFORE VALUE NOT
$      USED IN CALCULATION
OTT  3511021431P  B3237                     B3305   B3310    60 0.3  11
OTT   SE 0279KM 11  196 128 49              11  046 11 -095   0038397 49ML47MN
TNT  3511021431P                  X3311
TNT   S  0375KM         191-88    00 1601$                    0000000 00ML00MN
SHF  3511021431P  B3254                     B3339   B3356    80   2  90
SHF   E  0442KM 11 -092 094 49              11 -022 11  040   0035343 56ML50MN
INY  3511021431P                            X3410   X3410
INY   S  0529KM         162 49              00 1213$00 -957   0000000 00ML00MN
SFA  3511021431P  B3312                     B3408   B3436    60   2  35
```

```
SFA   E  0584KM 11 -032 086 49               11 -157 11  138   0018326 56ML50MN
AAM  3511021431P                             X3418
AAM   SW 0661KM         220 49               00 -790           0000000 00ML00MN
PHI  3511021431P                             C3454
PHI   S  0810KM         159 49               03 -358           0000000 00ML00MN
LRA  3511021431P                             X3838   X4018
LRA   SW 1783KM         225 52               00 1341$00 1500$  0000000 00ML00MN
             Z

+46.885- 79.004O MN=4.1 1011126 05111935 00.0000.000 0.0  1  2  10.76H210.00   0 1ML=4.6  10  0 3.65
$ NOVEMBER 5 1935, EVENT AT 10:11  - TIMISKAMING AFTERSHOCK
$ FELT IN TIMISKAMING
$ ONLY ONE STATION RECORDED THIS EVENT. READINGS OF SN AND SG WERE RECORDED.
$    ORIGIN TIME RECORDED IN 1935 WAS 10:10:48. USING VALUES GIVEN THE NEW
$    ORIGIN TIME IS 10:11:34.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK
$    CALCULATED MAGNITUDE IN 1935 OF ML=4.5.
SHF  3511051010P                             B1305   B1324    60 1.8   6
SHF   E  0479KM         092 49               10 -019 10  019   0003491 46ML41MN
             Z


+46.885- 79.004O MN=3.9 1647048 07111935 00.0000.000 0.0  1  1  10.00H210.00   0 1ML=4.2  10  0 3.65
$ NOVEMBER  7, 1935; EVENT AT 00:16:48
$ NO FELT REPORT
$  SMITH ESTIMATED INTENSITY II THEREFORE M 2.4
$ MAINSHOCK OF 19351101 EVENT USED AS EPICENTRE IN THIS LOCATION.
$ ?HODGESON NOTES "NOTE ON BIG CARDS SAYS THIS AFTERSHOCK ON NOV 7 OCCURRED AT
$   (LG) 16-4828 TO 16-4842  RATHER THAN 1148 AS ABOVE TAKEN FROM A
$   CORRELATION TABLE.  NO CARD #5856 OR ENTRY IN BULL IS AVAILABLE FOR CROSS
$   CHECK"
$ SMITH CHECKED THE MICROFILM AND FOUND NO TRACE AT EITHER HOUR
$ ADAMS CHECKED THE ORIGINAL OTT MILNE-SHAW RECORDS IN 1988 AND FOUND THE
$  TRACE AT 1648 ON THE EW MILNE-SHAW ONLY.  IT IS THREE PULSES EACH ABOUT
$  6 SEC APART ESTIMATED TO BE  0.2 MM Z-P @ 0.8 SEC
$ NOT ON SHF OR SFA ORIGINAL RECORDS (ADAMS, OCT 1988)
$ DUBIOUS MAGNITUDE
OTT  3511071647P                                     B4828   080 0.3 0.2
OTT   SE 0303KM         122 49                       10  000   0005236 42ML39MN
             Z
```

```
+46.885- 79.004O MN=3.9 1611197 15111935 00.0000.000 0.0  1  2  10.00H210.00   0 1ML=4.1  10  0 3.65
$ NOVEMBER 15 1935, EVENT AT 16:11  - TIMISKAMING AFTERSHOCK
$ ONLY ONE STATION RECORDED THIS EVENT, SN PHASE BEING RECORDED.
$    FIXED ORIGIN TIME OF 16:11:20. (1935)
$    RECORDED PHASE MAY BE SG, RESIDUALS AT FIXED ORIGIN TIME ARE BETTER.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    CALCULATED MAGNITUDE IN 1935 OF ML=3.0.
$ SMITH'S CARD HAS A COPY OF THE ORIGINAL OTT RECORD, PROBABLY MADE FROM
$   MICROFILM, THAT IS 2/3 SIZE OF ORIGINALS
$   AMPLITUDE/PERIOD READINGS OF OTT RECORD (1988) ARE .2 MM AT 0.9 SEC.
$ NOT ON SFA, SHF ORIGINAL RECORDS (ADAMS, OCT 1988)
OTT  3511151611P                            B1234   B1244    90 0.3   2
OTT   SE 0303KM         122 49              10 -105 10  105   0004654 41ML39MN
             Z

+46.885- 79.004O MN=4.3 0619246 25111935 00.0000.000 0.0  1  2  10.76H210.00   0 1ML=4.9  10  0 3.65
$ NOVEMBER 25 1935, EVENT AT 06:19  - TIMISKAMING AFTERSHOCK
$ FELT IN WIDDIFIELD AND MATTAWA AND NORTH BAY ONTARIO.
$ ONLY ONE STATION RECORDED THIS EVENT, WITH SN AND SG PHASES BEING RECORDED.
$    THE 1935 ORIGIN TIME WAS 06:19:19. RESIDUALS OF ABOUT 6 SEC. ARE GIVEN
$    WITH THIS FIXED RESIDUAL TIME.
$   A NEW ORIGIN TIME WAS CALCULATED, 06:19:25.4.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    CALCULATED MAGNITUDE IN 1935 OF ML=4.7.
$  NOT ON OTT OR SFA ORIGINAL RECORDS (ADAMS, OCT 1988)
SHF  3511250619P                            B2117   B2136    70 1.8  12
SHF   E  0479KM         092 49              10 -019 10  019   0005984 49ML43MN
             Z

+46.885- 79.004O MN=4.3 1931548 27111935 00.0000.000 0.0  1  1  10.76H210.00   0 1ML=4.8  10  0 3.65
$ NOVEMBER 27 1935, EVENT AT 19:31  - TIMISKAMING AFTERSHOCK
$ ONLY ONE STATION RECORDED THIS AFTERSHOCK. AN ORIGIN TIME WAS DETERMINED IN
$    1935 AND FOUND TO BE 19:31:49. THIS TIME GIVES ABOUT A 6 SEC. RESIDUAL.
$    SINCE THERE IS ONLY ONE PHASE, IT IS DIFFICULT TO DETERMINE THE PROPER
$    ORIGIN TIME. A NEW ORIGIN TIME WAS CALCULATED WITH ONLY THIS PHASE AND IS
$    19:31:54.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    CALCULATED MAGNITUDE IN 1935 OF ML=4.6.
$  NOT ON SFA OR OTT (ADAMS, OCT 1988)
SHF  3511271931P                                    B3406    60 1.8   9
SHF   E  0479KM         092 49                      10  000   0005236 48ML43MN
             Z
```

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+46.885- 79.004O MN=4.2 1040436 15121935 00.0000.000 0.0  1  2  10.00H210.00   0 1ML=4.7  10  0 3.65
$ DECEMBER 15 1935, EVENT AT 10:42  - TIMISKAMING AFTERSHOCK
$ FELT AT TEMISCAMING, SECOND AND LARGEST OF TWO WITHIN THE HOUR
$ LIKE "A CRACK OF THUNDER"
$ ASSIGNED MMI III BY SMITH SEE SMITH'S EVENT #419
$ ONLY ONE STATION RECORDED THIS EVENT, PRESUMED S PHASES
$    2ND S PHASE ONSET AT EDGE OF SHEET
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$ ORIGINAL SHF RECORD READ BY ADAMS IN 1988 AND GOOD TRACE FOUND
$ SFA RECORD BADLY FADED; NO TRACE
SHF  3512151042P                            B4241   C4250    60 1.8 0.8
SHF   E  0479KM         092 49              14  481 03 -481   0004654 47ML42MN
             Z

+47.885- 79.004O MN=4.2 0600095 20011936 00.0000.000 0.3  2  3  20.00H210.00   0 1ML=5.0  10  0 3.65
$ JANUARY 20 1936, EVENT 06:00  - TIMISKAMING AFTERSHOCK
$ FREE LOCATION
$+47.466- 79.604O MN=4.2 0600035 20011936 00.8010.510 0.4  3  5  23.52 210.00   0 1ML=5.1  10  0 3.6
$ FELT IN TIMISKAMING, MATTAWA AND NORTH BAY.
$ THREE STATIONS RECORDED THIS EVENT.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    CALCULATD MAGNITUDE IN 1935 OF ML=4.5.
$ BUF,SHF -READINGS WERE READ OFF COPIES OF THE ORIGINAL RECORDS.
$    SHF P-060817 P-0608305 RESIDUALS 6+ MINUTES ???
SHF  3601200601P  B0117          B01305          XB0233    70 2.2  17
SHF   E  0496KM 10  051 105 49    10  105            00  769   0006936 50ML44MN
BUF  3601200601P XB0110
BUF   S  0551KM 00 ****$179 49                                  0000000 00ML00MN
SFA  3601200601P                                    B0300    70 2.2   4
SFA   E  0622KM         095 49                      10  005   0001632 47ML40MN
             Z


+46.885- 79.004O MN=4.1 0127308 25031936 00.0000.000 0.0  1  1  10.76H210.00   0 1ML=4.7  10  0 3.65
$ MARCH 25 1936, EVENT AT 01:27  - TIMISKAMING AFTERSHOCK
$ FELT IN TIMISKAMING
$ ONLY ONE STATION RECORDED THIS EVENT. NO ORIGIN TIME WAS GIVEN SO THE SG
$    PHASE RECORDED DETERMINES THE TIME - 01:27:30.9.
$   A FIXED LOCATION WAS USED, IE. THAT OF THE MAINSHOCK.
$    CALCULATED MAGNITUDE IN 1935 OF ML=4.6.
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SHF  3603250127P                                    B2942    70 2.2   9
SHF   E  0479KM         092 49                      10  000   0003672 47ML41MN
             Z

+46.885- 79.004O MN=2.7 0017008 28071937 00.0000.000 0.0  1  1  00.76H210.00   0 1ML=0.0  00  0 3.65
$ JULY 28, 1937 ; EVENT AT 00:16:58
$ FELT AT TIMISKAMING
$  MMI= II-III (SMITH, 1966) (ML=2.7), TAKEN AS MN=2.7
$ THIS MAGNITUDE PROBABLY TOO LOW BY COMPARISON WITH OTHER FELT EQ
$ MAINSHOCK OF 19351101 EVENT USED AS EPICENTRE IN THIS LOCATION.
$ ONLY ONE STATION RECORDED THIS EVENT AND ONLY ONE PHASE WAS RECORDED.
$    AN EPICENTRE OF 46.72 N 79.08 W WAS STATED BY SMITH, 1966.
$    ORIGIN TIME DETERMINED BY SMITH WAS 00:17.
$    A NEW ORIGIN TIME WAS CALCULATED.
OTT  3707280017P                                    B1824
OTT   SE 0303KM         122 49                      10  000   0000000 00ML00MN
             Z

+46.885- 79.004O MN=3.0 1855488 12041938 00.0000.000 0.0  1  1  10.76H210.00   0 1ML=3.0  10  0 3.65
$ APRIL 12, 1938 ; EVENT AT 18:55:46
$ FELT IN TIMISKAMING
$ MAINSHOCK OF 351101 EVENT USED AS EPICENTRE IN THIS LOCATION.
$ ONLY ONE STATION RECORDED THIS EVENT AND ONLY ONE PHASE WAS RECORDED.
$    AN EPICENTRE OF 46.72 N 79.08 W WAS STATED IN SMITH, 1966.
$    ORIGIN TIME DETERMINED BY SMITH WAS 18:55:47
$    NEW ORIGIN TIME IS 18:55:46.9
$    A MAGNITUDE OF ML=3.2 WAS STATED (SMITH, 1966)
$   NOTE - USING ORIGINAL EPICENTRE GIVES AN ORIGIN TIME OF 18:55:49.8 FROM
$        COMPUTER CALCULATION.
OTT  3804121855P                                    B5712    40  81  30
OTT   SE 0303KM         122 49                      10  000   0000582 30ML30MN
             Z


+46.885- 79.004O MN=3.0 0034088 05011940 00.0000.000 0.0  1  3  10.76H210.00   0 1ML=3.0  10  0 3.65
$ JANUARY 5, 1940 ; EVENT AT 00:34:08
$ FELT IN TIMISKAMING
$ ONLY ONE STATION RECORDED THIS EVENT WITH THREE PHASES RECORDED.
$   ORIGIN TIME IN SMITH, 1966, OF 00:34:14
$   AN EPICENTRE OF 47.72 N 79.08 W WAS STATED BY SMITH, 1966.
$   SMITH REPORTED MAGNITUDE OF ML=3.0
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OTT  4001050034P                  B3458      B3526   B3530    30  73  22
OTT   SE 0303KM         122-88    10  017    10  187 10 -204   0000631 30ML30MN
             Z


+46.642- 78.625O MN=4.0 1250020 08031944 00.0770.105 0.2  3  6  30.79 210.00   0 1ML=4.4  20  0 3.65
$ MARCH 8, 1944 - EVENT AT 12:50
$ FELT IN TIMISKAMING (SMITH, 1966)
$ ORIGINAL LOCATION
$  46 41'- 78 52'   ML=4.1 1249561 (SMITH, 1966)
$ (46.680- 78.870)
OTT  4403081249P  B50415          B5045      B51095  B5116    50 6.9  65
OTT   SE 0268KM 10  022 120 49    10 -028    10 -024 10  054   0011838 43ML42MN
SHF  4403081249P                             X51545  B5205    70 2.2   7
SHF   E  0454KM         089 49               00  519 10 -139   0002856 45ML40MN
SFA  4403081249P                             X5226   B5248    50 2.2   2
SFA   E  0601KM         082 49               00  525 10  116   0001142 45ML38MN
             Z


+46.772- 78.950O MN=3.6 0459420 26041952 00.0360.045 0.3  3  6  30.47 210.00   0 1ML=3.7  30  0 3.65
$ APRIL 26, 1952 EVENT AT 04:59:41
$ FELT IN TIMISKAMING. (SMITH, 1966)
$  MAGNITUDE CALCULATED IN 1952 OF M=3.7
$ READINGS UNSURE IN TERMS OF SN-SG FOR KLC.
KLC  5204260500P  B0010                              B00295   50 7.8  25
KLC   NW 0173KM 11  025 332 49                       11 -006   0004028 33ML34MN
OTT  5204260500P                  B0029      C0052   B0103    2562.8  40
OTT   SE 0293KM         120-88    11 -043    03 -322 11  049   0001601 32ML34MN
SHF  5204260500P                                     B0152    50 2.2   5
SHF   E  0474KM         091 49                       11 -005   0002856 45ML40MN
             Z

+46.885- 79.004O MN=2.9 0341248 01111961 00.0000.000 0.0  1  3  10.88H210.00   0 1ML=2.8  10  0 3.65
$ NOVEMBER 1, 1961 ; EVNT AT 03:41:24
$ FELT IN TIMISKAMING
$ ONLY ONE STATION RECORDED THIS EVENT WITH THREE PHASES RECORDED.
$   MMI = II-III.
$   ORIGIN TIME (FROM 1961) 03:41:21
$   AN EPICENTRE OF 46.92 N 79.09 W (IN 1961)
$   REPORTED MAGNITUDE OF ML=2.9
$   A NEW ORIGIN TIME OF 03:41:24 WAS CALCULATED.
```

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OTT  6111010341P                  B42124     B42375  B4252    30  82  18
OTT   SE 0303KM         122-88    10 -139    10 -260 10  400   0000460 28ML29MN
             Z


+46.366- 78.980O1MN=3.6 1756331 15091965 00.1130.087 0.1  4  9  31.10 210.00   0 1ML=3.6  20F 0L3.65
$46.72 - 79.05   ML=3.8   CEEF 1989
$    FROM VONK
W. OF MATTAWA, ON
FELT IN NORTH BAY (TWO DOZEN REPORTS) AND ONE FROM READING
$    SEPTEMBER 15, 1965 ; EVENT AT 17:56
$    TWO DOZEN FELT REPORTS FROM NORTH BAY AND ONE FROM READING.
$    SMITH REPORT OF 1965 GIVES A MAGNITUDE READING OF M=3.8
$    46.72 - 79.05 (SMITH 1965 REPORT, CANADIAN EARTHQUAKES.)
$    LND PN VALUE ORIGINALLY RECORDED AS PG.
$
OTT  6509151756P  A57135                     A5742   B5753    3  067 100
OTT   E  0276KM 01  023 112 49               05 -046 26  434   0003126 35ML36MN
LND  6509151756P  B57331                     A58105  B5828    3  075  45
LND   SW 0409KM 17  354 206 49               03 -037 11  281   0001257 37ML35MN
MNT  6509151756P                                     B5830
MNT   E  0427KM         101 49                       00 -002   0000000 00ML00MN
SHF  6509151756P                                    XC5842
SHF   E  0478KM         085 49                       00 -216   0000000 00ML00MN
SFA  6509151756P                             B5854   B5928    3  132  40
SFA   E  0629KM         079 49               18 -367 09  256   0000635 41ML36MN
SCH  6509151756P                                    XB6222
SCH   NE 1274KM         038 49                       00 -025   0000000 00ML00MN
             Z

+46.928- 78.866F MN=3.9 1525114 19121975 00.0200.014 0.3 12 24 120.71 210.00   0 1ML=4.1  50  0 3.65
$ DECEMBER 19, 1975 ; EVENT AT 15:25:12
$ FELT AT TIMISKAMING, KIPAWA VILLAGE.
$47.00 - 78.85   MN=3.8 (1975 LOCATION)
$ DISHES AND WINDOWS RATTLED, MUFFLED RUMBLE HEARD.
$ NOT REPORTED FELT AT WEATHER STATIONS IN NORTH BAY, TIMMINS, VAL D'OR
$  SUDBURY, PETAWAWA, AND EARLTON.
$ FIRST SUDBURY (SUD) READING COULD BE EITHER PN OR PG, SECOND READING
$   COULD BE EITHER SN OR SG.
$  ALL VALUES AT POC OFF BY 2+ SEC. ARBITRARY TIME CORRECTION (2.1 SEC) ASSUMED
$
SUD  7512191525P                  B2539      B2557            20  88 420
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```
SUD   W  0169KM         253-87    10  032    10 -106           0014994 35ML40MN
MIQ  7512191525P  B2547                              B2615
MIQ   E  0231KM 10  088 105 49                       10  032   0000000 00ML00MN
OTT  7512191525P  B25545          B2559      B2626            20  94 330
OTT   SE 0297KM 10  029 124 49    10 -038    10  064           0011029 40ML42MN
MNT  7512191525P  B2611                      B2656   B2710    30 119 400
MNT   E  0435KM 10  002 109 49               10  139 10 -053   0007040 45ML43MN
CHQ  7512191525P  B2627                      B2724   B2750    30 153 130
CHQ   E  0577KM 10 -130 088 49               10 -083 10  058   0001780 43ML39MN
QCQ  7512191525P  B2628                      B2724   B2750    40  64  80
QCQ   E  0579KM 10 -061 089 49               10 -138 10 -015   0001963 44ML40MN
BNH  7512191525P  B26377
BNH   E  0647KM 10  084 111 49                                 0000000 00ML00MN
POC  7512191525P XC2642     -2.10           XC2747  XC2818    30 153  90
POC   E  0671KM 00  007 083 49               00 -005 00  056   0001232 44ML39MN
AGM  7512191525P  B26489
AGM   E  0749KM 10 -040 085 49                                 0000000 00ML00MN
MIM  7512191525P XC26508
MIM   E  0783KM 00 -261 100 49                                 0000000 00ML00MN
LHC  7512191525P                             B2813   B2850    50  43  20
LHC   W  0798KM         286 49               10  100 10 -014   0000584 45ML37MN
CBM  7512191525P XB26562
CBM   E  0818KM 00 -157 086 49                                 0000000 00ML00MN
MNQ  7512191525P  B2701                              B2903    40 110 110
MNQ   NE 0843KM 10  012 058 49                       10  049   0001571 49ML42MN
EMM  7512191525P  B27094
EMM   E  0916KM 10 -032 101 49                                 0000000 00ML00MN
PBQ  7512191525P                                              30  92  30
PBQ   N  0933KM         004 49                                 0000683 45ML39MN
UNB  7512191525P                                              50 157  17
UNB   E  0946KM         092 49                                 0000136 41ML32MN
SIC  7512191525P                                     X2939    50 106  25
SIC   NE 0965KM         064 49                       00  327   0000296 44ML35MN
SCH  7512191525P                             B2942   X3050    40  91  20
SCH   NE 1220KM         040 49               10  020 00  430   0000345 47ML38MN
             Z

+46.603- 78.695F1MN=4.3 0106399 13081982 00.0090.011 0.4 13 19 130.46 210.00   0 1ML=4.2  90  0 3.65
$ AUGUST 13 1982, EVENT AT 01:06:40
$  FREE DEPTH
$+46.611- 78.668F1MN=4.3 0106403 13081982 00.0080.019 0.4 13 18 130.39Z215.63  19 1ML=4.2  90  0 3.6
$ 1982 LOCATION
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$46.67  -78.53   MN=4.3 010642    DEPTH 18KM (ECTN BULLETIN)
$  EAST OF TIMISCAMING, QUEBEC
$  FELT MAXIMUM INTENSITY (IV). FELT SOUTHWARD TO 150 KM, BUT NORTHWARD
$   ONLY TO 100 KM. QUESTIONNAIRES SENT TO POSTMASTER AND SOME CLERGY.
$  UNSURVEYED AREA BETWEEN EPICENTRE AND 76 W IS SPARSELY POPULATED.
$  LITTLE SAMPLING DONE WEST OF 76 W.
$  EXTRA PHASE PICKED FROM DIGITAL RECORDS. -- VDQ PG
$   PHASES REPICKED FROM DIGITAL RECORDS.
$           PN -- VDQ,CKO,GAC,WEO,WBO,MNT,GNT,SBQ,JAQ
$           PG -- GAC      SG -- GAC
$RATIO=  2.073 CKO 075885C 0.10      30.51      32.51 071310 0.05    3610.51
CKO  8208130106P                  A065885C           A071301  10   9  87       3
CKO   SE 0117KM         125-85    14 -012            14  075   0060737 35ML43MN
SUD  8208130106P  A07082 D       XA07139             A0728    50  90 326
SUD   W  0175KM 14  034 266 49    00  568            14  004   0004552 34ML35MN
VDQ  8208130106P  A070901C        A071045D           A073233  12  16  88
VDQ   N  0189KM 14 -057 017 49    14 -004            14  051   0028798 37ML43MN
OTT  8208130106P  B071940+        X072584            B075255  10  25  85
OTT   SE 0267KM 04  032 119 49    00  277            04 -065   0021363 38ML45MN
GAC  8208130106P  A071857C       XB072619            B075208  28  15  91       3
GAC   E  0268KM 14 -062 111 49    00  298            04 -136   0013614 41ML43MN
WEO  8208130106P  B072193C                  XC07553           10  10  85       3
WEO   S  0289KM 04  024 175 49               00  324           0053407 44ML49MN
WBO  8208130106P  B07249 +                          XC08057   20  21  95
WBO   SE 0320KM 04 -065 123 49                       00 -202   0014212 42ML44MN
TRQ  8208130106P  A07258 C                          XC080652  18  24  75
TRQ   E  0321KM 14  004 096 49                       00 -150   0010908 41ML43MN
PTN  8208130106P  B07303
PTN   SE 0367KM 04 -102 127 49                                 0000000 00ML00MN
EFO  8208130106P  X0735                             XC0828    40  60 405
EFO   S  0393KM 00  051 187 49                       00  022   0010603 47ML44MN
MNT  8208130106P  X073764                           XB083425  18  34  87
MNT   E  0411KM 00  097 105 49                       00  157   0008932 44ML44MN
APH  8208130106P  B07405
APH   SE 0451KM 04 -101 131 49                                 0000000 00ML00MN
GNT  8208130106P  B074486E                          XB085245  43  17  95
GNT   E  0486KM 04 -096 091 49                       00 -080   0008166 49ML45MN
INY  8208130106P XC07450 C
INY   S  0495KM 00 -185 158 49                                 0000000 00ML00MN
SBQ  8208130106P XC075330                    X08458 XC09081   34  32  76
SBQ   E  0542KM 00  068 102 49               00 -021 00 -036   0004389 46ML43MN
QCQ  8208130106P XB07545 D
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QCQ   E  0568KM 00 -128 085 49                                  0000000 00ML00MN
CLE  8208130106P                  X08150
CLE   SW 0612KM         203 49    00 -371                       0000000 00ML00MN
LMQ  8208130106P XB0803  D
LMQ   E  0644KM 00 -211 078 49                                  0000000 00ML00MN
LPQ  8208130106P XC080551                       XB094228  48  70 416
LPQ   E  0666KM 00 -223 080 49                   00 -019   0007779 54ML47MN
GPD  8208130106P XC08120
GPD   SE 0708KM 00 -088 150 49                                  0000000 00ML00MN
ACM  8208130106P XC08153
ACM   SW 0718KM 00  121 235 49                                  0000000 00ML00MN
MIM  8208130106P XB08180
MIM   E  0764KM 00 -168 098 49                                  0000000 00ML00MN
PRIN 8208130106P XB08196
PRIN  SE 0764KM 00 -008 154 49                                  0000000 00ML00MN
EBN  8208130106P XB08245 C                       X10210
EBN   E  0800KM 00  040 079 49                   00  180   0000000 00ML00MN
AN1  8208130106P  X08267
AN1   SW 0810KM 00  142 215 49                                  0000000 00ML00MN
LHC  8208130106P                        XB09453 XC1025    50  67  23
LHC   W  0821KM         288 49           00 -011 00  004   0000431 44ML36MN
JAQ  8208130106P  C082624+              XB09461 XC102645  42 195 350
JAQ   N  0829KM 01 -138 014 49           00 -099 00 -063   0002685 51ML44MN
MNQ  8208130106P  C082930D               X09557 XB103495  45 108 365
MNQ   NE 0852KM 01 -119 056 49           00  361 00  147   0004719 54ML46MN
UNB  8208130106P                                 X1057
UNB   E  0932KM         090 49                   00  156   0000000 00ML00MN
CVL  8208130106P XC08430
CVL   S  0958KM 00 -037 179 49                                  0000000 00ML00MN
SIC  8208130106P  X08475                 X1020   X11105
SIC   NE 0970KM 00  271 061 49           00  297 00  485   0000000 00ML00MN
BLA  8208130106P XC08555
BLA   S  1053KM 00  049 188 49                                  0000000 00ML00MN
SCH  8208130106P  X09145
SCH   NE 1240KM 00 -327 038 49                                  0000000 00ML00MN
ORT  8208130106P XC09207
ORT   SW 1277KM 00 -155 203 49                                  0000000 00ML00MN
FVM  8208130106P XC09315
FVM   SW 1359KM 00 -073 229 49                                  0000000 00ML00MN
FCC  8208130106P  X10170
FCC   NW 1700KM 00  317 328 49                                  0000000 00ML00MN
FFC  8208130106P  X10300 +
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FFC   NW 1867KM 00 -351 307 50                                 0000000 00ML00MN
FRB  8208130106P  X10450
FRB   N  2012KM 00 -462 015 47                                 0000000 00ML00MN
BDW  8208130106P XC11353
BDW   W  2469KM 00 -064 271 39                                 0000000 00ML00MN
             Z

+46.846- 78.879F1MN=3.3 2131258 10011983 00.0110.025 0.3  9 17 180.34 210.00   0 1ML=3.3 100  0 3.65
$ JANUARY 10 1983, EVENT AT 21:31:28
$  FREE DEPTH
$+46.850- 78.880F1MN=3.3 2131257 10011983 00.0130.026 0.3  9 17 180.34Z2 8.88  20 1ML=3.3 100  0 3.6
$  1983 LOCATION
$+46.822- 78.845F1MN=3.3 2131265 10011983 00.0110.025 0.3  9 17 180.34 218.00   0 1ML=3.3 100  0 0.0
$ GSC PN PHASE WAS REPICKED FROM DIGITAL RECORDS.
$ VDQ PG PHASE WAS PICKED.
$ GRQ PG PHASE WAS PICKED.
$ OTT PN PHASE FROM ISC WAS USED AS THE PG PHASE.
$ FIRST MOTIONS WERE RECORDED FOR MANY OF THE PHASES.
$ 140 KM NW FROM CHALK RIVER, ONT.
CKO  8301102131P                  A314905-           B32069
CKO   SE 0145KM         130-86    22 -028            05  117   0000000 00ML00MN
SUD  8301102131P  B31534                             C3212   020 085 075         1
SUD   W  0165KM 05  080 256 49                       01  075   0002772 27ML32MN
VDQ  8301102131P  A315281+        B315326-   C321125 B321290 016 117 255         1
VDQ   NE 0168KM 22 -017 024 49    05  018    01 -121 05  080   0008559 32ML37MN
GRQ  8301102131P  A320102-        X320246+   B322565         023 209 398         1
GRQ   E  0232KM 22  023 095 49    00 -094    05 -043           0005202 34ML37MN
GAC  8301102131P  B320852-        B321350            B324592                     1
GAC   SE 0291KM 05  056 115 49    05  060            05  016   0000000 00ML00MN
OTT  8301102131P                 XB32135            XB32458  013 615 160         1
OTT   SE 0293KM         122-88    00  034            00 -041   0001257 29ML33MN
WEO  8301102131P                                     X325380 012 463 300       3 1
WEO   S  0317KM         173 49                       00  106   0003393 34ML38MN
WBO  8301102131P  C32162                    XC325252 X33041  0151067 230         1
WBO   SE 0347KM 01  147 125 49               00  212 00  314   0000903 30ML33MN
KAO  8301102131P  B32209                    XB3300           020 314 071         1
KAO   NW 0395KM 05  032 318 49               00 -060           0000710 32ML33MN
EFO  8301102131P                                    XB33185  020 116 025         1
EFO   S  0419KM         185 49                       00 -216   0000677 33ML33MN
MNT  8301102131P                                    XB33258  0151778 238         1
MNT   E  0433KM         108 49                       00  137   0000561 31ML32MN
GNT  8301102131P                                    XB33446  030 721 242         1
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GNT   E  0502KM         094 49                       00  128   0000703 37ML34MN
QCQ  8301102131P                             X3347  XB3406   030 036 035         1
QCQ   E  0581KM         088 49               00  690 00  107   0002036 43ML40MN
LMQ  8301102131P  X32502                     X34005  X3430   020 289 040         1
LMQ   E  0653KM 00 -187 080 49               00  495 00  524   0000435 37ML34MN
LPQ  8301102131P                                    XB34331                      1
LPQ   E  0676KM         082 49                       00  207   0000000 00ML00MN
GTO  8301102131P  C32559                     X34020          020 376 020         1
GTO   NW 0681KM 01  042 301 49               00  051           0000167 34ML30MN
EBN  8301102131P  X330915                   XC34308 XC35115  0351186 135         1
EBN   E  0810KM 00 -200 081 49               00  196 00  383   0000204 39ML32MN
MNQ  8301102131P  B33154 +                   X34405 XB35203  030 533 055         1
MNQ   NE 0849KM 05 -062 057 49               00  318 00  179   0000216 39ML33MN
PBQ  8301102131P                                    XB3545   040 093 007         1
PBQ   N  0942KM         004 49                       00  091   0000118 39ML31MN
KLN  8301102131P                                    XC35508  0401383 065         1
KLN   E  0954KM         085 49                       00  364   0000074 37ML29MN
SIC  8301102131P                                     X3555   050 151 008         1
SIC   NE 0970KM         063 49                       00  346   0000067 38ML29MN
SXO  8301102131P                             X3518   X3612   040 139 004         1
SXO   NW 1034KM         295 49               00  133 00  279   0000045 36ML28MN
             Z


+46.838- 78.798F1MN=2.8 0949229 27111983 00.0110.019 0.3 10 16 100.38 210.00   0 1ML=2.5  90  0 3.65
$ NOVEMBER 27, 1983, EVENT AT 0949
$ FREE DEPTH
$+46.867- 78.794F1MN=2.8 0949224 27111983 00.0120.015 0.3 10 16 100.28Z2 2.88  22 1ML=2.5  90  0 3.6
$ 1983 LOCATION
$+46.805- 78.768O1MN=2.9 0949236 27111983 00.0250.054 0.4 10 15 110.72 218.00   0 1ML=2.6 100  0 0.0
$ VDQ PG PHASE PICKED
CKO  8311270949P                  A49452 C           B50016   11 240 150
CKO   SE 0140KM         132-86    21 -036            05  024   0003570 25ML32MN
VDQ  8311270949P  A49496 D        B49500 +   B50091           16 236 151
VDQ   N  0167KM 21 -028 022 49    05  008    05 -012           0002513 26ML32MN
SUD  8311270949P  B49508                             B5010    40 104  23
SUD   W  0171KM 05  042 257 49                       05  009   0000347 22ML23MN
GRQ  8311270949P  A49575 +                           B50254   15 456 166
GRQ   E  0226KM 21  039 095 49                       05  041   0001525 27ML32MN
GAC  8311270949P  B50054 +                           B50410   301289 169
GAC   SE 0285KM 05  110 115 49                       05 -020   0000275 25ML26MN
OTT  8311270949P                  X50074             C50415   103200 203
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OTT   SE 0287KM         123-88    00 -192            01 -022   0000399 22ML28MN
WEO  8311270949P  X50105          X50124            XC50505   10 470 177       3
WEO   S  0315KM 00  255 174 49    00 -142            00  114   0002366 31ML36MN
TRQ  8311270949P  B50108 +                          XB50542   121580 119
TRQ   E  0333KM 05  064 100 49                       00  004   0000394 25ML29MN
WBO  8311270949P  C50113                                      112085 107
WBO   SE 0341KM 01  018 125 49                                 0000293 24ML28MN
KAO  8311270949P  B50190                 X5056   X5111    30 209  20
KAO   NW 0400KM 05  076 318 49               00 -270 00 -146   0000200 29ML27MN
GTO  8311270949P  B50537                XB52006          30 210   3
GTO   NW 0687KM 05  044 301 49               00  081           0000030 28ML23MN
             Z


+46.843- 78.927O1MN=1.6 1144396 20051985 00.0260.073 0.0  3  5  20.10 210.00   0 1ML=0.8  30  0 3.65
$ MAY 20, 1985 EVENT AT 11:44
$+46.850- 78.880O1MN=1.6 1144390 20051985 0 0.01 0.02 0.0  3  5  20.20Z2 6.00   0
$ EEO DILATATION WEAK
$ ORIGINAL PICKFILE NOTES THAT A SIMILAR EVENT ON MAY 22 AT 09:09
$  WAS TOO SMALL TO LOCATE. (CEEF FILES)
EEO  8505201144P                  A44441 D           A44470  0051408 395    0  0
EEO   SW 0025KM         207-68    16  009            16 -007   0003525 08ML29MN
CKO  8505201144P                                     C45201  0082500  25
CKO   SE 0148KM         129-86                       01 -009   0000079 07ML16MN
VDQ  8505201144P  B45066                             C45262  0152000  30    0  0
VDQ   NE 0170KM 04 -038 025 49                       01 -018   0000063 10ML16MN
             Z

+47.018- 79.057O1MN=1.7 0525045 01101986 00.0280.020 0.2  3  5  20.14 210.00   0 1ML=1.1  30  0 3.65
$ OCTOBER 10, 1986, EVENT AT 05:25
$ FREE DEPTH  (STILL 10 KM)
$+47.020- 79.056O1MN=1.7 0525045 01101986 00.0000.000 0.2  3  4  20.05Z210.00 990 1ML=1.1  30  0 3.6
$ 1986 LOCATION
$+47.000- 79.070O1MN=1.7 0525040 01101986 1 0.03 0.02 0.2  3  5  20.30 218.00   0 0  =0.0  00  0 3.6
TEMISCAMING, QUE.
EEO  8610010525P            -0.06 A251161D           B251635 007 100  18    0  0
EEO   S  0042KM         182-77    20  000            05 -013   0001616 12ML28MN
CKO  8610010525P            -0.06 C253395            B255085 010 100   1    0  0
CKO   SE 0168KM         132-87    01  218            05  012   0000063 08ML16MN
GRQ  8610010525P            -0.09                    B261262 010 100   1    0  0
GRQ   E  0248KM         099 49                       05 -016   0000063 12ML19MN
             Z
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+46.844- 78.894F1MN=3.2 0132106 17081987 00.0120.014 0.2 10 14 120.37 210.00   0 5ML=2.7  90  0 3.65
$ AUGUST 17, 1987. EVENT AT 01:32
$ LOCATION DETERMINED WITH FOCAL MECHANISM.
$+46.818- 78.895F1MN=3.2 0132109 17081987 00.0120.013 0.2 11 15 120.37Z214.41   0 5ML=2.7  90  0 3.6
$  FREE DEPTH
$+46.812- 78.906F1MN=3.2 0132111 17081987 00.0120.009 0.2 11 15 120.24Z215.72  13 5ML=2.7  90  0 3.6
$  CEEF FILE
$+46.874- 78.897F1MN=3.2 0132101 17081987 00.0120.009 0.2 11 15 120.24 218.00  13 5ML=2.7  90  0 3.6
$RATIO= -0.198 EEO 321574D 0.00   -3280.78    328078 321904 0.07    2080.78
EEO  8708170132P            -0.06 A321572D           B321903 007 100 264    0  0
EEO   SW 0026KM         211-69    15  040            04  051   0023697 18ML38MN
CKO  8708170132P            -0.06 B323393+           B325171 010 100  51    0  0
CKO   SE 0146KM         130-86    04 -040            04  091   0003204 24ML32MN
SWO  8708170132P XA323646+   0.00                   XB325523 010 100  72    0  0
SWO   W  0161KM 00 -048 266 49                       00  026   0004524 26ML34MN
SUO  8708170132P  A323759C   0.00                    B325676 017 100  56    0  0
SUO   W  0169KM 15 -030 254 49                       04 -036   0002070 26ML31MN
SZO  8708170132P XA324167+   0.00                   XB330648 010 100  73    0  0
SZO   W  0204KM 00 -051 258 49                       00 -027   0004587 29ML36MN
GRQ  8708170132P  A324610+  -0.09                    B331495 013 100  54    0  0
GRQ   E  0234KM 15  027 095 49                       04  012   0002610 29ML35MN
GAC  8708170132P  A325234+  -0.06                   XB332948 000   0   0    0  0
GAC   SE 0292KM 15 -061 114 49                       00 -142   0000000 00ML00MN
WEO  8708170132P XC325707   -0.07                    X333719 000   0   0    0  0
WEO   S  0317KM 00  112 172 49                       00 -042   0000000 00ML00MN
TRQ  8708170132P  B325899+  -0.09              X333646XB334255 020 100  22    0  0
TRQ   E  0340KM 04  011 100 49                 00  248 00 -145   0000691 30ML31MN
WBO  8708170132P  C330019+  -0.06                   XB334586 023 100  18    0  0
WBO   SE 0348KM 01  049 125 49                       00 -020   0000492 30ML30MN
KAO  8708170132P  C33045 E   0.00              X33405  X3355  030 315  67    0  0
KAO   NW 0394KM 01 -082 319 49                 00 -479 00 -372   0000045 00ML21MN
EFO  8708170132P  X33100
EFO   S  0419KM 00  171 185 49                                   0000000 00ML00MN
GNT  8708170132P            -0.06                   XB342927 023 100  21    0  0
GNT   E  0503KM         094 49                       00  077   0000574 35ML33MN
LMQ  8708170132P XB33395 C
LMQ   E  0654KM 00  247 080 49                                   0000000 00ML00MN
LPQ  8708170132P            -0.22                   XB351540 053 100  18    0  0
LPQ   E  0677KM         082 49                       00 -098   0000213 39ML31MN
GTO  8708170132P  A33401 +   0.00             XB34455 XB3515   040 235  17    0  0
GTO   NW 0680KM 15 -009 301 49                 00 -062 00 -200   0000114 35ML29MN
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JAQ  8708170132P  A335599   -0.07           XB351141XB355039 037 100  11    0  0
JAQ   N  0807KM 15  027 015 49               00 -175 00 -141   0000187 39ML32MN
MNQ  8708170132P XC340342   -0.10                   XB360401 033 100   7    0  0
MNQ   NE 0850KM 00  235 057 49                       00  028   0000133 38ML31MN
             Z

+46.578- 78.838O1MN=1.8 2036068 29091987 00.1870.113 0.5  4  5  20.57 218.00   0 1ML=1.4  20  0 3.65
$ ONE OF THE UNLOCATED EVENTS NEAR EEO ONTARIO
$ LOCATED SOUTHEAST OF TEMISCAMING QUEBEC
$ LARGE ERROR RESIDUAL FOR LOCATION (20 KM.)
$ NO DIGITAL TIME SERIES FOR THIS EVENT (EEO SPIKY, WOULD BE ONLY ONE TO
$   TRIGGER)
$ GAC PROBABLY NOISE, LMQ TO FAR AWAY.
$ LOCATION HAS POOR AZIMITHAL COVERAGE ALLGOOD STATIONS TO THE WEST.
EEO  8709292036P                  A36110 D           A36134
EEO   W  0019KM         291-47    15 -011            15 -072   0000000 00ML00MN
SWO  8709292036P                                     B36535   20 209   3
SWO   W  0166KM         277 49                       04  082   0000045 10ML14MN
SUO  8709292036P                                     C36545
SUO   W  0168KM         264 49                       01  147   0000000 00ML00MN
SZO  8709292036P                                     B37045   30 209 1.5
SZO   W  0205KM         267 49                       04  139   0000150 19ML21MN
GAC  8709292036P                 XB36315
GAC   E  0277KM         109-86    00 ****$                     0000000 00ML00MN
LMQ  8709292036P                                    XC38585
LMQ   E  0656KM         077 49                       00 -799   0000000 00ML00MN
             Z

+46.819- 78.816F1MN=2.1 1127535 17021988 00.0180.010 0.2  3  6  50.11 210.00   0 1ML=1.3  60  0 3.65
$ FEBRUARY 17 1988, EVENT AT 11:27:53
$ TIMISKAMING AREA
$ FREE DEPTH
$+46.854- 78.791F1MN=2.2 1127531 17021988 00.0400.019 0.3  6 11  40.29Z2 2.07  51 1ML=1.4  50  0 3.6
$ ORIGINAL LOCATION
$+46.671- 78.859  DEPTH 18 KM.  (10 KM SW OF NEW LOCATION )
$ CKO FIRST ARRIVAL ORIGINALLY READ AS PN, PROBABLY PG (137 KM FROM EPICENTRE)
$ SUO,SZO PHASES OK BUT ONLY SWO PHASES USED FOR LOCATION.
EEO  8802171127P            -0.06 A275839D           B280166 013 100  24    0  0
EEO   SW 0028KM         225-70    21  002            05 -007   0001160 08ML25MN
CKO  8802171127P            -0.06 B281577            B283203 0131000  38    0  0
CKO   SE 0139KM         131-86    05 -036            05  014   0000184 13ML19MN
SWO  8802171127P  B282073    0.00                    B283918 0071000  59    0  0
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SWO   W  0167KM 05  025 268 49                      05 -021   0000530 16ML25MN
SUO  8802171127P XB282169    0.00                  XB284177 0131000  32    0  0
SUO   W  0174KM 00  036 255 49                      00  045   0000155 13ML20MN
SZO  8802171127P XB282725    0.00                  XB285161 0131000  38    0  0
SZO   W  0210KM 00  159 259 49                      00  058   0000184 16ML22MN
GRQ  8802171127P           -0.09            X284990         0101000  17    0  0
GRQ   E  0227KM         095 49              00 -283           0000107 14ML20MN
             Z


+46.334- 75.687F1MN=4.0 1442555 10031988 00.0040.007 0.4 18 24 230.30Z213.44  10 1ML=3.9 180F 0 0.00
                                        OUEST DU QUEBEC
FELT MODERATELY (IV) IN MANIWAKI,       RESSENTI MODEREMENT (IV) A MANIWAKI,
STE.FAMILLE D'AUMOND,                   SAINTE-FAMILLE D'AUMOND,
STE.THERESE-DE-LA-GATINEAU,             SAINTE-THERESE-DE-LA-GATINEAU,
LAC-DES-TRENTE-ET-UN-MILLE, QUE.        LAC-DES-TRENTE-ET-UN-MILLE, QUE.
FELT MIDLY (III) IN                     RESSENTI LEGEREMENT (III) A
LAC-DES-BOIS-FRANCS, LAC CAYAMANT       LAC-DES-BOIS-FRANCS, LAC CAYAMANT
NOTRE-DAME-DU-LAUS, VAL-BARETTE,        NOTRE-DAME-DU-LAUS, VAL-BARETTE,
MONT-LAURIER, GRAND REMOUS,             MONT-LAURIER, GRAND REMOUS,
AND VAL-LIMOGES, QUE.                   ET VAL-LIMOGES, QUE.
ALSO FELT VERY LOCALLY IN OTTAWA        AUSSI RESSENTI TRES LOCALEMENT A OTTAWA
WESTERN QUEBEC
$ CALL FROM JOHN CARR, OTTAWA, (613) 729-6032
$ 3 STORY APT. BUILDING, TOP FLOOR OFF SHILLINGTON/FISHER BED SHOOK MILDLY
$ METEO STATION IN MANIWAKI FELT IT LIKE FURNACE EXPLOSION (HEARD NOISE)
$ MANY PHONE CALLS FROM MANIWAKI
$RATIO=  0.519 GRQ 430169C 0.17    2343.09    5300.91 43 584 0.09    7732.91
$RATIO=  0.264 GAC 430776C 0.19    1857.02    1857.02 431472 0.22    3410.98
$RATIO=  0.032 TRQ 431025D 0.16    -382.79    1034.21 431683 0.13     412.21
$RATIO=  0.917 OTT 431278C 0.13      91.10     270.10 432393 0.15     751.90
GRQ  8803101443P           -0.09 A430170C           A430581 007 1001836           430650
GRQ   NW 0033KM         336-68    12  024           12  009   0164799 30ML47MN
GAC  8803101443P           -0.06 A430775C           A431590
GAC   S  0072KM         167-79    12  027           12 -029   0000000 00ML00MN
TRQ  8803101443P           -0.09 A431025D           A432042 013 100 765           432221
TRQ   E  0088KM         098-81    12  016           12 -028   0036974 33ML39MN
OTT  8803101443P           -0.06 A431276C           A432563 017 1001059           432617
OTT   S  0105KM         181-83    12  009           12  043   0039141 35ML40MN
CKO  8803101443P           -0.06 A431834D           A433520 020 1001005           433788
CKO   W  0141KM         255-85    12 -023           12 -025   0031573 37ML42MN
WBO  8803101443P           -0.06 A431993C           B433793 010 100 297           434205
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WBO   S  0152KM         168-85    12 -031            03 -042   0018661 32ML40MN
MNT  8803101443P  A432464+  -0.06                   XB434614 013 100 314           434831
MNT   SE 0185KM 12  023 119 49                       00 -148   0015176 34ML40MN
DPQ  8803101443P  A432980C  -0.06                   XA435773 017 100 284           435869
DPQ   E  0227KM 12  029 079 49                       00 -155   0010497 36ML40MN
EEO  8803101443P  B433488E  -0.06XB433644D          XA440702 013 100 139           441073
EEO   W  0262KM 03  100 279 49    00 -160            00 -224   0006718 34ML39MN
SBQ  8803101443P XC434340   -0.07                   XB442062 033 1001659           442275
SBQ   E  0311KM 00  360 109 49                       00 -223   0031587 47ML47MN
WEO  8803101443P  C434277   -0.07                   XC442820 010 100 293           444080
WEO   SW 0333KM 01  028 220 49                       00 -085   0018410 41ML46MN
SUO  8803101443P XB43563 -
SUO   W  0410KM 00  454 273 49                                 0000000 00ML00MN
SWO  8803101443P  B43527 -
SWO   W  0410KM 03  086 278 49                                 0000000 00ML00MN
A54  8803101443P  X431376   +45.0                    X440647 022 100 130
A54   E  0421KM 00  560 071 49                       00 -212   0003713 41ML40MN
LMQ  8803101443P XB43542 +
LMQ   E  0430KM 00 -007 070 49                                 0000000 00ML00MN
A11  8803101443P  X430921   +45.0                    X441011 023 100 079
A11   E  0431KM 00 -018 074 49                       00 -138   0002158 39ML38MN
LPQ  8803101443P  C435656+  -0.22XC440325           XC445928 027 100 137           450111
LPQ   E  0448KM 01 -003 073 49    00 -478            00 -195   0003188 42ML40MN
A16  8803101443P  X431875   +45.0                    X441524 023 100 79
A16   E  0451KM 00  700 072 49                       00 -167   0021581 50ML48MN
A61  8803101443P  X431136   +45.0                    X441585 023 100 085
A61   E  0452KM 00 -054 068 49                       00 -133   0002322 40ML39MN
A64  8803101443P  X431347   +45.0                    X441879 035 100 66
A64   NE 0471KM 00 -071 067 49                       00 -368   0011848 49ML46MN
A21  8803101443P  X431493   +45.0                    X442305 025 100 121
A21   E  0481KM 00 -049 069 49                       00 -230   0003041 42ML40MN
SLQ  8803101443P XB44121 +
SLQ   E  0529KM 00  576 071 49                                 0000000 00ML00MN
EBN  8803101443P  B441341   -0.22           XC451174 X453713 047 100  64           454553
EBN   E  0581KM 03  052 075 49               00  157 00 -152   0000856 41ML36MN
HTQ  8803101443P            -0.07                   XC454803 027 100  34           455150
HTQ   NE 0632KM         057 49                       00 -482   0000791 41ML36MN
MNQ  8803101443P  B442598C  -0.10                   XC460535 020 100  14           462300
MNQ   NE 0693KM 03 -042 045 49                       00 -438   0000440 38ML35MN
GGN  8803101443P            -0.29                    X460769 067 100  43           462261
GGN   E  0703KM         098 49                       00 -523   0000403 42ML34MN
GSQ  8803101443P  A442753   -0.22           XC453941 X461357 047 100  46           462561
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GSQ   NE 0706KM 12 -055 063 49               00  273 00  008   0000615 43ML36MN
KLN  8803101443P  A442954+  -0.29           XA453977 X461181 033 100  22           461811
KLN   E  0716KM 12  009 082 49               00  076 00 -473   0000419 40ML35MN
JAQ  8803101443P  B444255   -0.07           XC460071XB464409 033 100  30           464895
JAQ   N  0831KM 03 -072 360 49               00 -258 00 -448   0000571 44ML37MN
GTO  8803101443P XB44561 -
GTO   NW 0922KM 00  187 298 49                                 0000000 00ML00MN
SCH  8803101443P  B45197 +
SCH   NE 1134KM 03 -044 030 49                                 0000000 00ML00MN
$RATIO=  0.533 GRQ 430170C 0.16    2285.36    5358.64 43 584 0.09    7790.64
GRQ  8803101443P            -0.09

+46.828- 78.834F1MN=2.3 2224242 22081988 00.0310.017 0.2  6 11  50.46 210.00   0 1ML=1.6  60  0 3.65
WESTERN QUEBEC                          OUEST DU QUEBEC
EEO  8808222224P            -0.06 A242909D            243254 013 100  99           243271
EEO   SW 0028KM         221-70    26 -002            07  009   0004785 15ML31MN
CKO  8808222224P   244957   -0.06                     250287 0131000  61           250383
CKO   SE 0141KM 07  146 131 49                       07 -024   0000295 15ML21MN
SWO  8808222225P   245074                             250966 0071000  80           251228
SWO   W  0166KM 07 -034 267 49                       07 -014   0000718 17ML26MN
SUO  8808222225P                                      251125 0171000  45           251739
SUO   W  0173KM         255 49                       07 -055   0000166 15ML20MN
SZO  8808222225P   245728                             252122 0101000  36           252190
SZO   W  0209KM 07  100 259 49                       07 -026   0000226 16ML23MN
GRQ  8808222224P   245934   -0.09                    B252589 0131000  28           252746
GRQ   E  0229KM 07  050 095 49                       07 -122   0000135 16ML21MN
             Z

+46.798- 78.829F1MN=2.6 1824031 11101988 00.0350.018 0.2  6 12  50.51 210.00   0 1ML=2.0  60  0 3.65
KIPAWA SEISMIC ZONE                     ZONE SEISMIQUE KIPAWA
$ADD REGIONALS WHEN AVAILABLE
EEO  8810111824P            -0.06 A240744D            241067 010 100 215           241099
EEO   SW 0026KM         227-69    28 -018            07 -006   0013509 17ML35MN
CKO  8810111824P            -0.06 C242571             244281 013 100  11           244476
CKO   SE 0139KM         130-86    02  010            07  152   0000532 17ML24MN
SWO  8810111824P   242987                             244922 010 100  16           245147
SWO   W  0166KM 07 -007 268 49                       07  054   0001005 20ML28MN
SUO  8810111824P  C243122                             245080 013 100  14           245321
SUO   W  0173KM 02  049 256 49                       07  031   0000677 20ML26MN
SZO  8810111824P   243659                             250014 013 100  17           250143
SZO   W  0208KM 07  151 260 49                       07 -010   0000822 23ML29MN
GRQ  8810111824P   243777   -0.09                     250475 0171000  95           250784
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GRQ   E  0228KM 07  017 094 49                       07 -103   0000351 21ML26MN
             Z

+46.863- 78.864O1MN=1.3 0155410 15101988 00.0000.000 0.0  2  3  10.00 2 0.00   0 1ML=0.4  20  0 3.65
KIPAWA SEISMIC ZONE
$ FREE LOCATION STARTED AT LOCATION OF EVENT ON OCT 11, 1988
$ PERHAPS 3 KM FURTHER TO ENE
$ SLTN DIDNT TRIGGER
EEO  8810150155P            -0.06 A554584            A554915 0131000  48           554960
EEO   SW 0029KM         213-90    12  000            12  000   0000232 02ML18MN
CKO  8810150155P            -0.06                    B562095 0139999  78           562311
CKO   SE 0145KM         131-90                       03  000   0000038 06ML13MN
             Z
```

APPENDIX C

MAGNITUDE THRESHOLD TEST OF THE TIMISKAMING AREA

```
  LAT     LONG    MAG       TIME                                     DEPTH

+46.874- 78.897F1MN=3.2 0132101 17081987 00.0100.012 1.2 12 17 110.00N210.00   0 5ML=2.9
110 0 3.65
$ THRESHOLD TEST OF TIMISKAMING AREA.
$ LOCATION OF EVENT THAT OF ORIGINAL LOCATION OF AUGUST, 17 1987 EVENT
$ ALL STATION (EXCEPT EEO) HAVE AN AMPLITUDE OF 2.0 MM AND A PERIOD OF 0.3 SEC
$     K (MAGNIFICATON) VALUES DETERMINED OR ASSUMED FROM CHART
$              OF PERIOD VS INSTRUMENT TYPE. (OBSERVATORY)
$       CKO-GRQ SET AT 327 (GNT VALUE)
$ VDQ-OTT-SHF-MNQ ARBITRARILY SET PHASES.
$   ALL SET AT MARK3-MONITOR 3 WHERE POSSIBLE.
$    MAGNITUDE THRESHOLD BOUNDARIES.
$   ---------------------------------
$ OTTM - MILNE-SHAW INSTRUMENT, OTTAWA STATION, 1922
$ SHF - WOOD-ANDERSON INSTRUMENT, SHAWINIGAN FALLS STATION, 1927
$ OTTB - BENIOFF INSTRUMENT, OTTAWA STATION, 1937
$ SUD - 1967
$ VDQ-CKO - 1980
$ EEO - 1984
$STATION  DATE      PN              PG        SN       SG    T   K  AMP
EEO  8708170132P           -0.06 A321572D           B321896 010 600 020    0  0
EEO   SW 0029KM        208-58    29 -001            07 -066   0000209 00ML18MN
CKO  8708170132P           -0.06 B323393            B325171 030 327 020    0  0
CKO   SE 0148KM        131-83    07 -031            07  065   0000128 15ML18MN
SUD  8708170132P  B323646    0.00                   B325523 030 109 020    0  0
SUD   W  0165KM 07  053 255 49                      07 -030   0000384 21ML24MN
VDQ  8708170132P  X323692   -0.07           B325341 B325539 030 390 020    0  0
VDQ   NE 0166KM 00  075 024 49              07 -149 07 -059   0000107 15ML18MN
GRQ  8708170132P  X324608   -0.09                   B331489 030 327 020    0  0
GRQ   E  0234KM 00  161 096 49                      07  036   0000128 19ML21MN
OTTB 8708170132P  X325108   -0.09                   B333189 030 073 020    0  0
OTTB  SE 0296KM 00 -090 123 49                      07  049   0000574 29ML30MN
OTTM 8708170132P  X325108   -0.09                   B333189 030 0.3 020    0  0
OTTM  SE 0296KM 00 -090 123 49                      07  049   0139626 53ML53MN
KAO  8708170132P  X330392   -0.07           B334241 B335839 030 209 020    0  0
KAO   NW 0392KM 00  027 318 49              07 -043 07  082   0000200 28ML27MN
SHF  8708170132P  X331408   -0.09                   B341829 060 2.3 020    0  0
SHF   E  0471KM 00  080 092 49                      07 -092   0009106 50ML45MN
SHF  8708170132P  X331408   -0.09                   B341829 030 2.3 020    0  0
SHF   E  0471KM 00  080 092 49                      07 -092   0018212 51ML48MN
SHF  8708170132P  X331408   -0.09                   B341829 030 073 020    0  0
SHF   E  0471KM 00  080 092 49                      07 -092   0000574 36ML33MN
MNQ  8708170132P  X340008   -0.09                   B360289 030 324 020    0  0
MNQ   NE 0849KM 00  064 058 49                      07  015   0000129 37ML31MN
             Z
```

APPENDIX D Recurrence Calculations for Kipawa Zone

```
Mx = 6.5
     MINIMUMMAGNITUDE 1.5  MAXIMUM MAGNITUDE 6.5  MAGNITUDE' INCREMENT 0.5
     LASTYR=        1988
     REJECT EVENT :  19372.7
     YEAR      1984   1980   1967   1937   1937   1928   1928   1928   1900   1900   1840 1800
     MAGS.     1.50   2.00   2.50   3.00   3.50   4.00   4.50   5.00   5.50   6.00   6.50
     EV.NOS.      2      1      0      5      1      3      0      1      0      1      0
     STRT.YR   1984   1980   1967   1937   1937   1928   1928   1928   1900   1900   1900
     INTVS.       5      9     22     52     52     61     61     61     89     89     89
     INCR.RT  0.400  0.111  0.000  0.096  0.019  0.049  0.000  0.016  0.000  0.011
     ERRUP    2.320  3.300  0.084  1.676  3.300  1.973  0.030  3.300  0.021  3.300
     ERRDUN   0.354  0.173  0.000  0.568  0.173  0.457  0.000  0.173  0.000  0.173
     CUM.RT.  0.703  0.303  0.192  0.192  0.096  0.077  0.028  0.028  0.011  0.011
     ERRUP    1.267  1.289  1.302  1.302  1.597  1.676  2.320  2.320  3.300  3.300
     ERRDUN   0.733  0.711  0.698  0.698  0.603  0.568  0.354  0.354  0.173  0.173
     LOW AND HIGH MAGS USED:  1.50 6.0
     FOR THE A PRIORI MX OF 6.5
     BETA=  0.8921 1 STDV OF 0.226  B= 0.3874 1 STDV OF 0.098
     TOTAL NUMBER OF EVENTS   14
     LOG(ANNUAL RATE ABOVE M0) 0.288
     ANNUAL RATE ABOVE M5 0.0224 1 STDV OF 0.006
--------------------------------------------------------------------------
Mx = 7.0
     MINIMUMMAGNITUDE 1.5  MAXIMUM MAGNITUDE 7.0  MAGNITUDE' INCREMENT 0.5
     LASTYR=        1988
     REJECT EVENT :  19372.7
     YEAR      1984   1980   1967   1937   1937   1928   1928   1928   1900   1900   1840 1800
     MAGS.     1.50   2.00   2.50   3.00   3.50   4.00   4.50   5.00   5.50   6.00   6.50
     EV.NOS.      2      1      0      5      1      3      0      1      0      1      0
     STRT.YR   1984   1980   1967   1937   1937   1928   1928   1928   1900   1900   1900
     INTVS.       5      9     22     52     52     61     61     61     89     89     89
     INCR.RT  0.400  0.111  0.000  0.096  0.019  0.049  0.000  0.016  0.000  0.011
     ERRUP    2.320  3.300  0.084  1.676  3.300  1.973  0.030  3.300  0.021  3.300
     ERRDUN   0.354  0.173  0.000  0.568  0.173  0.457  0.000  0.173  0.000  0.173
     CUM.RT.  0.703  0.303  0.192  0.192  0.096  0.077  0.028  0.028  0.011  0.011
     ERRUP    1.267  1.289  1.302  1.302  1.597  1.676  2.320  2.320  3.300  3.300
     ERRDUN   0.733  0.711  0.698  0.698  0.603  0.568  0.354  0.354  0.173  0.173
     LOW AND HIGH MAGS USED:  1.50 6.00
     FOR THE A PRIORI MX OF 7.0
     BETA=  0.9183 1 STDV OF 0.219  B= 0.3988 1 STDV OF 0.095
     TOTAL NUMBER OF EVENTS   14
     LOG(ANNUAL RATE ABOVE M0) 0.310
     ANNUAL RATE ABOVE M5 0.0207 1 STDV OF 0.006
--------------------------------------------------------------------------
Mx = 7.5
     MINIMUMMAGNITUDE 1.5  MAXIMUM MAGNITUDE 7.5  MAGNITUDE' INCREMENT 0.5
     LASTYR=        1988
     REJECT EVENT :  19372.7
     YEAR      1984   1980   1967   1937   1937   1928   1928   1928   1900   1900   1840 1800
     MAGS.     1.50   2.00   2.50   3.00   3.50   4.00   4.50   5.00   5.50   6.00   6.50
     EV.NOS.      2      1      0      5      1      3      0      1      0      1      0
     STRT.YR   1984   1980   1967   1937   1937   1928   1928   1928   1900   1900   1900
     INTVS.       5      9     22     52     52     61     61     61     89     89     89
     INCR.RT  0.400  0.111  0.000  0.096  0.019  0.049  0.000  0.016  0.000  0.011
     ERRUP    2.320  3.300  0.084  1.676  3.300  1.973  0.030  3.300  0.021  3.300
     ERRDUN   0.354  0.173  0.000  0.568  0.173  0.457  0.000  0.173  0.000  0.173
     CUM.RT.  0.703  0.303  0.192  0.192  0.096  0.077  0.028  0.028  0.011  0.011
     ERRUP    1.267  1.289  1.302  1.302  1.597  1.676  2.320  2.320  3.300  3.300
     ERRDUN   0.733  0.711  0.698  0.698  0.603  0.568  0.354  0.354  0.173  0.173
     LOW AND HIGH MAGS USED:  1.50 6.00
     FOR THE A PRIORI MX OF 7.5
     BETA=  0.9346 1 STDV OF 0.214  B= 0.4059 1 STDV OF 0.093
     TOTAL NUMBER OF EVENTS   14
     LOG(ANNUAL RATE ABOVE M0) 0.324
     ANNUAL RATE ABOVE M5 0.0197 1 STDV OF 0.005
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Calculations by program Betapl by D. Weichert- F. Anglin