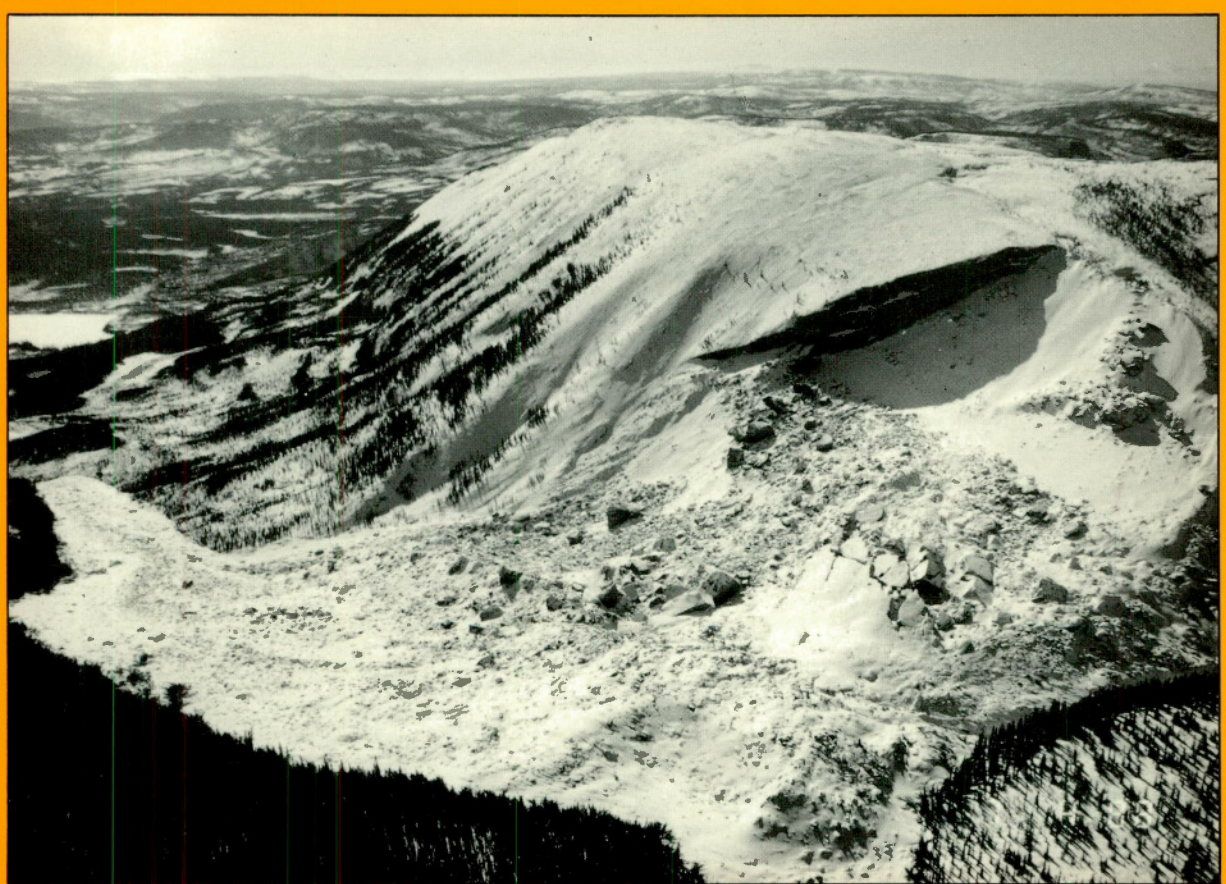
GEOLOGICAL SURVEY OF CANADA
PAPER 88-14

CANADIAN EARTHQUAKES — 1985-86



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Energy, Mines and Resources Canada
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NOTE

The format of the annual catalogue of Canadian earthquakes produced by the Geophysics Division and the Cordilleran and Pacific Geoscience Division of the Geological Survey of Canada has been changed with this edition. This catalogue covers two years of activity, only lists events with magnitude 4.0 or greater and is also available in a French version. Subsequent editions will be published every other year. More detailed information about Canadian earthquakes is available in the form of quarterly reports prepared by the Geological Survey. Enquiries about Canadian earthquakes, earthquake hazards or seismological research in Canada should be directed to the Geophysics Division, 1 Observatory Crescent, Ottawa, Ontario, K1A 0Y3 (613-995-5548) or the Pacific Geoscience Centre, 9860 West Saanich Road, Sidney, B.C., V8L 4B2 (604-356-6500).

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Cover photo

Aerial view of the English Chief rock avalanche which was triggered by the magnitude 6.6 Nahanni earthquake of 5 October 1985. The avalanche, which is the fourth largest known in Canada in this century, incorporated almost 7 million cubic metres of rock and spread out over a distance of 1.5 km from its start. It occurred on the northeast face of the English Chief anticline located about 15 km north of the epicentre of the earthquake in the District of Mackenzie, Northwest Territories.

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CANADIAN EARTHQUAKES — 1985-86

Abstract

During the two year period 1985-86, 169 earthquakes of magnitude 4.0 and greater occurred in or near Canada. The location and magnitude for these events are listed chronologically in a table following the text and are shown on maps for all regions of the country. Events smaller than magnitude 4.0 are also shown on the maps but are not listed in the tables. The larger events included two magnitude 6 events in the Nahanni region of the Northwest Territories and six magnitude 5 events, three in British Columbia, one in the Yukon Territory, one in the Northwest Territories and one in the Lake Erie region of northern Ohio which affected most of southern Ontario.

Information on 69 earthquakes reported felt in Canada during this period is given in a second table. The distribution of felt reports for five widely felt earthquakes are shown on regional maps.

The report also gives information on 32 important earthquakes that have occurred in Canada in this century. The locations of these events are shown on the regional seismicity maps and a summary of the events is given in the Appendix. Also shown are the distribution of seismograph stations in Canada, the distribution of the active plate boundary features around Canada and the relative distribution of long-term seismic hazard in Canada.

INTRODUCTION

Canadian earthquakes are studied by seismologists in the Geophysics Division (GD) and the Cordilleran and Pacific Geoscience Division of the Geological Survey of Canada (GSC). The research centres for the two groups are located in Ottawa, Ontario and in Sidney, B.C.

Analysis procedures

The earthquake parameters listed in this report are determined by the GSC with information collected from all seismograph stations operating in Canada during this period. The analysis procedures are similar to those described by Wetmiller et al. (1983) and Drysdale et al. (1985) with the exception that only earthquakes with magnitude 4.0 or greater are documented here, although smaller magnitude activity is plotted on the maps. Information about any events shown in this report including those smaller than magnitude 4.0 is available on request.

In the present report earthquake times and dates are always given in Greenwich Mean Time (GMT) not local time; thus, there will be some variance with the times given in local press reports of the events listed here. Note that the origin times given here are generally not in error by more than a few seconds. Geographic co-ordinates are given for the epicentre of each event. The epicentral determirations are generally not accurate to more than a few kilometres and may be in error by as much as 20 km or more in some cases. Focal depth is the most difficult earthquake parameter to determine and depths given here should be regarded as approximate only.

Magnitudes are based on the Richter magnitude scale, although they are calculated in several different ways. The magnitude scale is a logarithmic scale, so a 1-unit increase in magnitude is equivalent to a 10-fold increase of earthquake "size". Magnitude 3 earthquakes are generally big enough to be felt (if they are located close to populated areas) and magnitude 5 are generally big enough to cause minor property damage.

The GSC surveys the area affected in Canada for any earthquake reported felt, either by telephone or by mail for widely felt events, and analyzes the reports in terms of the 12-point Modified Mercalli intensity scale. Intensities I-III represent mild shaking, IV-VI represent moderate to strong shaking and intensities VII-XII describe various levels of property damage. The felt reports collected in 1985-86 are summarized for every felt event in a separate table and, if sufficient data are available, plotted on an isoseismal map.

In addition to these catalogues on Canadian Earthquakes, GSC prepares various quarterly reports on current seismic activity in Canada, which are available free of charge to interested agencies. All earthquake data are maintained in a digital database which can be searched for specific information on a modest cost-recovery basis. Please contact the Geophysics Division for information about these services.

Seismograph networks

Figure 1 shows the distribution of permanent seismograph stations in Canada operated by the GSC in 1985-86 for the purpose of studying Canadian Earthquakes and which have been used to locate the earthquakes summarized in this report.

Detailed notes regarding the stations' instrumentation, calibrations and any changes to the stations in 1985-86 can be found in the reports "Canadian Seismograph Operations" for 1985 and 1986 (Munro et al., 1987, 1988).

The magnification levels of these seismograph stations during 1985 and 1986 allowed the location of most seismic events of magnitude 3.5 or greater anywhere in Canada or its offshore areas. Detection of earthquake was poorest in the Northwest Territories because of the wide spacing of stations in the north. However, in the Vancouver Island-B.C. lower mainland area, the Queen Charlotte Islands and parts of the St. Lawrence Valley and Ottawa Valley of Quebec and Ontario, the closer spacing of the stations permitted the location of most events above magnitude 2.0. Within the dense arrays of the southern Vancouver Island-B.C. lower mainland area and the Charlevoix, Quebec area, many events smaller than magnitude 1.0 have been located.

Significant Canadian earthquakes

Although Canada is not well known for earthquake activity, a number of important earthquakes have occurred in its history: 27 deaths in an earthquake-generated tsunami on the southern Newfoundland coast in 1929; millions of dollars of earthquake damage in Cornwall, Ontario in 1944 and again on southern Vancouver Island in 1946. The Appendix lists 32 important earthquakes that have occurred in or near Canada in this century. It does not list just the larger earthquakes, but those which, by virtue of their size and location, have been significant to the understanding of earthquake activity in Canada. The locations of these important events are shown with the activity for 1985-86 on the seismicity maps throughout the text for comparison.

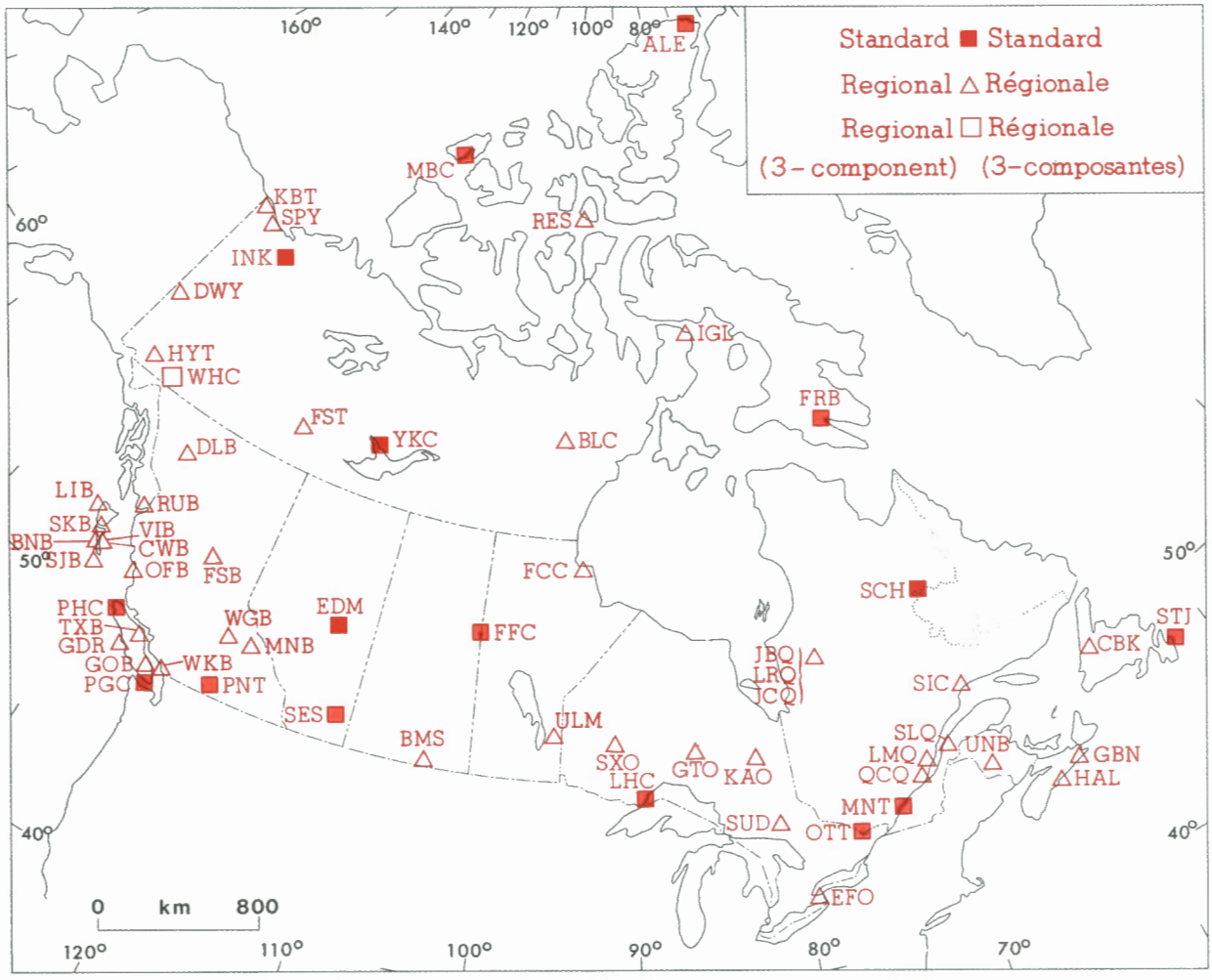

Figure 1a. Standard and regional seismograph stations operated by the Geological Survey of Canada. Standard stations have 3-component long- and short-period sensors; all others have a single component short-period sensor except where noted.

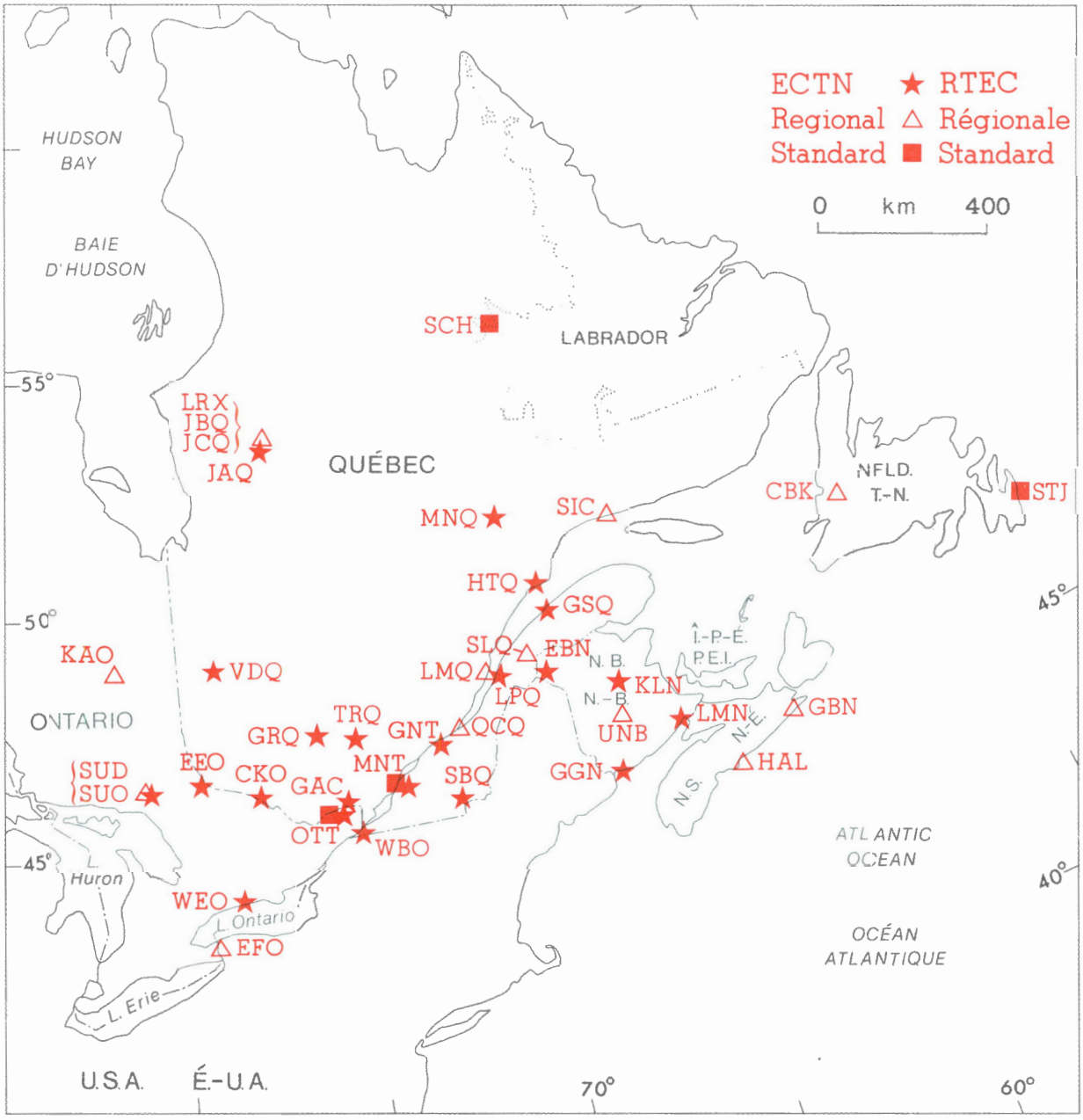

Figure 1b. The Eastern Canada Telemetred Network. ECTN stations are digital telemetry stations linked to computers at the Geophysics Division, Ottawa. The other stations record on paper records at their sites.

Plate boundary features

In order to understand the distribution of earthquake activity throughout Canada, it is necessary to be aware of the location of large plates which are setting the stage for earthquake activity by slowly moving relative to one another. Figure 2 shows the distribution of those plates that affect Canada. Most earthquakes in the world occur on the active faults that form the boundaries of such plates. Earthquakes of this type are termed interplate earthquakes.

Three general types of plate boundaries are recognized: rift zones or speading ridges where new (oceanic) crust is created, subduction zones where old crust is destroyed, and strike-slip zones where crustal plates simply move past each other and material is neither created nor destroyed. Examples of these three types of zones occur along the west coast of British Columbia where they represent the interactions of the Pacific and North American plates and some smaller plates in this region. The active faults are located primarily in the offshore areas, but do affect onshore areas directly on Vancouver Island (subduction), the Queen Charlotte Islands (strike-slip) and the southern Yukon (strike-slip and subduction). These areas are thus subject to more frequent earthquake activity and to a higher risk of large damaging earthquakes than other parts of Canada.

Significant earthquake activity also occurs within the crustal plates away from the plate boundaries. Such earthquakes are called intraplate earthquakes and are not as well understood as the interplate earthquakes. It is thought that the stresses and strains generated by the plate movements can spread over a wide area inside the plates and trigger earthquakes on old existing faults of other zones of weakness. Thus even though eastern Canada is well away from the nearest plate boundary, a spreading ridge located in the mid-Atlantic, significant earthquake activity does occur in eastern Canada which seems to have characteristics related to the compressive stresses that may be being generated in the North American plate by that rift boundary.

SUMMARY OF SEISMIC ACTIVITY FOR 1985-86

Larger earthquakes

There were 169 earthquakes of magnitude 4.0 or greater in Canada or its environs in 1985-86 (Table 1, Fig. 3). The largest were magnitude 6.6 and 6.9 earthquakes which took place along the North Nahanni River in the Mackenzie Mountains of the Northwest Territories on 5 October and 23 December 1985 respectively. These earthquakes have been

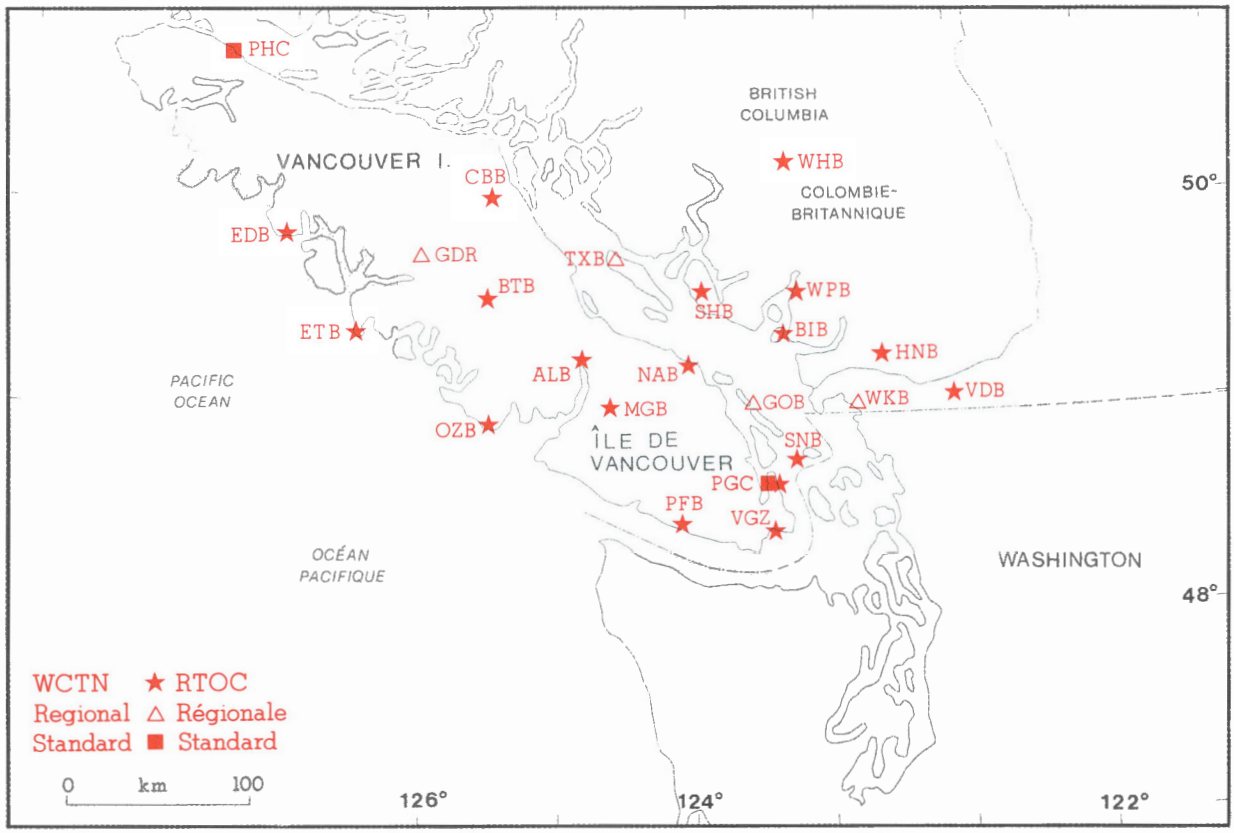

Figure 1c. The Western Canada Telemetred Network. WCTN stations are digital telemetry stations linked to computers at the Pacific Geoscience Centre, Sidney, B.C. The other stations record on paper records at their sites.

called the Nahanni earthquakes and are the most important earthquakes to occur in Canada in several years (see Wetmiller et al., (1988) for a summary of the studies of these events). Eight magnitude 5 earthquakes occurred as part of the strong aftershock activity that followed the Nahanni earthquakes. Other important events in 1985-86 included a magnitude 5.0 event near Cleveland, Ohio, on 31 January 1986 (Cajka and Stevens, 1986; Stover, 1986), a magnitude 5.4 earthquake near Prince George, B.C. on 23 March 1986 (Rogers et al., 1988) and a magnitude 5.2 earthquake on the west coast of Vancouver Island on 16 June 1986. These five events were all widely felt in the areas surrounding them, but they did not cause any significant property damage because they were all located away from areas of dense population. Three other magnitude 5 earthquakes occurred: magnitude 5.7 on 9 January 1985 in the southern Yukon Territory, magnitude 5.4 on 15 September 1985 in the northwestern corner of British Columbia and magnitude 5.0 on 22 April 1986 in the Beaufort Sea. Each of these events was located in a remote area and they were reported felt only mildly or, in the latter case, not at all.

Felt earthquakes

There were 69 earthquake tremors reported felt in Canada in 1985-86 (Table 2). These included the five strong ones noted above, which were widely felt, and many others, with magnitudes less than 4.0, which were felt only over a small area. By region, 18 tremors were reported felt in both B.C. and Quebec, 12 in the N.W.T., eight each in Alberta and New Brunswick, four in Ontario, three in Newfoundland and Labrador and two in Saskatchewan. The strongest shaking (intensities V-VI) occurred in the Mackenzie Mountains, N.W.T. accompanying the Nahanni earthquakes on 5 October and 23 December 1985 and in eastern B.C. on 21 March 1986 with the Prince George earthquake. Milder tremors (intensities III-IV) affected most of southern Ontario with the Ohio earthquake on 31 January 1986 and central Vancouver Island with the earthquake on 16 June 1986.

Figure 2. Present configuration of crustal plates and their boundary zones. Subduction zones are zones of plate convergence where underthrusting occurs and old crust is consumed, rift zones are zones of divergence where rifting occurs and new crustal material is produced and strike-slip zones are zones of strike-slip faulting.

Table 1. Canadian earthquakes magnitude ≥ 4.0, January 1985 to December 1986.

No.	Date	Time	Lat° N	Long° W	Mag	Depth	LOCATION AND COMMENTS
001	1985/01/09	19:27	60.294	110.717	5.7	15.	YUKON-ALASKA BORDER NEAR MT. ST. ELIAS. FELT ALONG THE ALASKA HIGHWAY FROM BEAVER CREEK TO WHITEHORSE. ALSO FELT AT YAKUTAT(IV) AND CAPE YAKATAGA(II), ALASKA.
002	1985/01/11	13:07	47.910	122.870	3.1	20.	OLYMPIC PENINSULA, WASHINGTON. FELT (IV) AT QUILCENE AND (III) AT POULSBO, BRINNON AND PORT GAMBLE. ALSO FELT AT PORT TOWNSEND, WASHINGTON AND IN THE GORDON HEAD AREA OF VICTORIA, B.C.
003	1985/01/17	07:23	48.820	56.880	3.0	1.	POSSIBLE ROCKBURST AT BUCHANS, NFLD. FELT FOR 5-10 SEC, MANY PEOPLE AWAKENED. NO ONE UNDERGROUND IN THE MINE.
004	1985/01/28	04:25	47.140	65.860	2.6	5.	MIRAMICHI REGION, N.B. FELT AT NEWCASTLE
005	1985/02/11	21:57	47.600	69.940	2.7	12.	FELT IN THE CHARLEVOIX REGION, QUE.
006	1985/02/18	09:45	47.440	70.190	2.7	14.	CHARLEVOIX REGION, QUE. FELT AT ST-HILARION AND LA MALBAIE, QUE.
007	1985/03/03	12:14	47.390	70.480	3.1	14.	CHARLEVOIX REGION, QUE. FELT IN ST-HILARION, CLERMONT, ILE-AUX-COUDES AND BAIE-ST-PAUL, QUE.
008	1985/03/11	12:99	52.190	115.270	3.9	5.	SOUTHWESTERN ALBERTA FELT OVER A SMALL AREA ABOUT 20 KM SOUTHWEST OF ROCKY MOUNTAIN HOUSE.
009	1985/03/22	14:36	48.820	56.850	2.6	2.	FELT IN BUCHANS, NFLD. NOT AS STRONG AS JANUARY EVENT
010	1985/04/06	19:43	52.240	106.880	2.9	1.	INDUCED EARTHQUAKE. FELT(IV) AT THE CORY POTASH MINE, WEST OF SASKATOON, SASK.
011	1985/04/10	05:51	47.520	69.960	3.1	12.	CHARLEVOIX REGION, QUE. FELT ST HILARION, QUE.
012	1985/05/09	04:08	62.213	141.287	4.3	2.	YUKON TERRITORY. FELT (IV) AT BEAVER CREEK, WHITE RIVER LODGE AND KOIDERN. ALSO FELT AT STEWART RIVER.
013	1985/05/14	06:21	48.670	123.230	2.5	21.	HARO STRAIT, WASHINGTON. FELT (III) ON MOST OF SAANICH PENINSULA INCLUDING SIDNEY AND THE GORDON HEAD AND OAK BAY AREAS OF VICTORIA, B.C. ALSO FELT ON SOME OF THE GULF ISLANDS.
014	1985/07/30	17:01	48.400	123.320	3.0	15.	OFF VICTORIA WATERFRONT. FELT ON SAANICH PENINSULA AND SOUTHERN VANCOUVER ISLAND FROM SOOKE TO SIDNEY. MAXIMUM INTENSITY (IV) IN VICTORIA.
015	1985/08/06	13:53	49.250	116.840	4.0	18.	SOUTHERN BRITISH COLUMBIA. FELT AT TRAIL AND CRESTON, B.C. FELT (IV) AT CUSICK, WASHINGTON AND NORDMAN, IDAHO. FELT (III) AT IONE, NEWPORT, METALINE AND USK, WASHINGTON. ALSO FELT AT PRIEST RIVER AND PORTHILL, IDAHO.
016	1985/08/20	16:27	53.820	132.720	3.2	18.	NORTHERN QUEEN CHARLOTTE ISLANDS, B.C. FELT AT LANGARA ISLAND.
017	1985/08/24	06:03	45.680	76.650	3.1	18.	EASTERN ONTARIO. FELT IN RENFREW
018	1985/08/24	11:39	52.290	115.440	3.8	5.	SOUTHWESTERN ALBERTA. FELT IN AN AREA 25 KM SOUTHWEST OF ROCKY MOUNTAIN HOUSE. FELT AFTERSHOCKS AT 14:35 AND 25 AUG 22:40.
019	1985/08/24	14:33	52.190	115.270	2.9	5.	SOUTHWESTERN ALBERTA. AFTERSHOCK. FELT MILDLY ABOUT 25 KM SOUTHWEST OF ROCKY MOUNTAIN HOUSE.
036	1986/01/10	09:59	45.800	77.320	3.3	18.	EASTERN ONTARIO. FELT IN PEMBROKE (IV), LOCKSLEY AND PETAWAWA. MOST PEOPLE THOUGHT IT WAS A SNOWPLOUGH
037	1986/01/11	03:04	47.270	70.400	2.8	10.	FELT IN CHARLEVOIX REGION, QUE.
038	1986/01/11	13:29	47.710	70.120	4.0	5.	FELT IN CHARLEVOIX REGION, QUE.
039	1986/01/31	16:45	41.700	81.180	5.0	5.	PAINESVILLE, OHIO NEAR CLEVELAND. FIFTEEN PEOPLE TREATED FOR MINOR INJURIES. SOME DAMAGE IN EPICENTRAL AREA. FELT FROM WISCONSIN TO MARYLAND. IN CANADA PERCEPTIBLE TO ABOUT 420 KM, MAXIMUM INTENSITY V. FELT WIDELY THROUGHOUT SOUTHWESTERN ONTARIO (III-IV) AND NORTH TO MUSKOKA, EAST TO BELLEVILLE. SEE FIGURE 5.
040	1986/02/05	05:43	47.320	70.590	2.8	13.	CHARLEVOIX REGION, QUE. FELT IN ST-HILARION, BAIE-ST-PAUL AND ST-PLACIDE
041	1986/02/10	12:08	56.410	120.780	3.1	5.	NORTHEASTERN BRITISH COLUMBIA. FELT AT FORT ST. JOHN, B.C.
042	1986/02/13	20:36	62.103	124.212	5.4	10.	MACKENZIE MOUNTAINS, N.W.T. AFTERSHOCK. FELT AT WRIGLEY, FORT SIMPSON, NAHANNI BUTTE AND FORT LIARD, N.W.T. 160 KM W FROM FORT SIMPSON, N.W.T.
043	1986/02/16	02:46	66.520	135.420	4.8	18.	NORTHERN YUKON TERRITORY. FELT AT FORT MCPHERSON, AKLAVIK, AND INUVIK, N.W.T. NOT FELT AT DAWSON.
044	1986/02/20	15:21	62.136	124.224	4.4	10.	MACKENZIE MOUNTAINS, N.W.T. FELT AT WRIGLEY AND FORT SIMPSON.
045	1986/03/06	08:33	47.000	66.600	3.4	5.	MIRAMICHI REGION, N.B. FELT IN BATHURST
046	1986/03/20	04:49	60.710	137.450	2.5	5.	SOUTHWESTERN YUKON TERRITORY FELT AT HAINES JUNCTION
047	1986/03/21	22:41	54.270	132.890	3.2	10.	QUEEN CHARLOTTE ISLANDS FELT AT LANGARA ISLAND, B.C.
048	1986/03/21	23:55	54.240	122.000	5.4	10.	EASTERN BRITISH COLUMBIA. FELT STRONGLY IN THE PRINCE GEORGE AREA. MAXIMUM INTENSITY (VI) AT WILLOW RIVER, GISCOME, UPPER FRASER AND SINCLAIR MILLS. SEE FIGURE 12.
049	1986/04/20	09:59	57.384	59.509	4.8	18.	LABRADOR SEA. FELT BY SEVERAL PEOPLE WHO WERE AWAKENED IN NAIN, LABRADOR. NOT FELT 90 KM S OF NAIN. NOT FELT IN HOPEDALE.
050	1986/05/03	23:05	62.152	124.193	4.9	10.	MACKENZIE MOUNTAINS, N.W.T. FELT AT FORT SIMPSON.
051	1986/05/09	09:04	46.549	66.124	3.3	18.	EASTERN NEW BRUNSWICK. FELT IN DOAKTOWN
052	1986/06/16	15:54	49.431	127.017	5.2	35.	OFF WEST COAST OF VANCOUVER ISLAND. FELT INTENSITY (IV) ON NORTHERN VANCOUVER ISLAND. ALSO FELT IN THE VANCOUVER AREA AND IN NORTHWESTERN WASHINGTON. SEE FIGURE 10.
053	1986/06/20	05:02	50.410	64.340	3.4	18.	FELT IN LOWER ST. LAWRENCE VALLEY, QUE. INTENSITY IV : MINGAN, LONGUE POINTE RIVIERE-ST-JEAN, MAGPIE, PORT-MENIER RIVIERE-AU-TONNERRE, SHELDRAKE. INTENSITY III: HAVRE-ST-PIERRE AFTERSHOCK MAGNITUDE 2.1 FELT INTENSITY III AT MAGPIE, LONGUE-POINTE AND MINGAN
054	1986/07/04	08:54	62.157	124.248	4.8	10.	MACKENZIE MOUNTAINS, N.W.T. FELT AT WRIGLEY, FORT SIMPSON AND NAHANNI BUTTE, N.W.T.

Tableau 1. (cont.)

020	1985/08/25	22:39	52.170	115.270	2.5	5.	SOUTHWESTERN ALBERTA. AFTERSHOCK. FELT MILDLY ABOUT 25 KM SOUTHWEST OF ROCKY MOUNTAIN HOUSE.
021	1985/08/29	09:26	48.460	124.050	2.4	11.	SOUTHERN VANCOUVER ISLAND. FELT MILDLY NEAR SOOKE.
022	1985/09/01	12:08	52.220	115.280	3.8	5.	SOUTHWESTERN ALBERTA. FELT OVER A SMALL AREA 25 KM SOUTHWEST OF ROCKY MOUNTAIN HOUSE.
023	1985/09/03	09:26	45.402	72.685	2.4	9.	SOUTHERN QUEBEC. FELT NEAR GRANBY
024	1985/09/15	01:28	59.133	136.554	5.4	2.	SOUTHEASTERN ALASKA. FELT (V) AT HAINES AND GUSTAVUS, (IV) AT SKAGWAY, PELICAN AND JUNEAU, (III) AT AUKE BAY, ELFIN COVE, KAKE, HOONAH AND YAKUTAT, ALASKA. ALSO FELT AT HAINES JUNCTION, WHITEHORSE AND CARCROSS, Y.T.
025	1985/10/05	05:34	47.000	66.600	3.9	5.	MIRAMICHI REGION, N.B. FELT IN BATHURST
026	1985/10/05	15:24	62.208	124.217	6.6	6.	MACKENZIE MOUNTAINS, N.W.T. FELT STRONGLY WITH SLIGHT DAMAGE AT WRIGLEY, FORT SIMPSON AND FORT LIARD. FELT IN PARTS OF THE YUKON TERRITORY, BRITISH COLUMBIA AND ALBERTA. ALSO FELT AT JUNEAU AND SITKA, ALASKA. LANDSLIDES OBSERVED IN THE EPICENTRAL REGION NEAR THE NORTH NAHANNI RIVER. SEE FIGURE 8.
027	1985/10/06	01:15	62.058	124.292	5.0	10.	MACKENZIE MOUNTAINS, N.W.T. LARGEST AFTERSHOCK. FELT AT FORT SIMPSON, FORT LIARD, WRIGLEY AND NAHANNI BUTTE, N.W.T.
028	1985/10/13	20:56	62.170	124.290	3.6	10.	MACKENZIE MOUNTAINS, N.W.T. FELT AND HEARD BY FIELD PARTIES
029	1985/10/16	10:22	54.650	128.630	2.8	10.	COAST MOUNTAINS, B.C. FELT AT TERRACE WHERE A FEW PEOPLE WERE AWAKENED.
030	1985/11/01	23:32	45.286	73.485	3.4	12.	SOUTHEAST OF MONTREAL, WEST OF ST-JEAN FELT LOCALLY
031	1985/11/02	14:44	46.000	75.760	2.5	18.	WESTERN QUEBEC, NORTH OF OTTAWA FELT BY HUNTERS IN THE AREA
032	1985/12/23	05:15	62.187	124.243	6.9	10.	MACKENZIE MOUNTAINS, N.W.T. FELT (V) AT WRIGLEY, FORT SIMPSON AND NAHANNI BUTTE, N.W.T. FELT (III-IV) OVER LARGE PARTS OF THE YUKON, BRITISH COLUMBIA AND ALBERTA. ALSO FELT IN THE STATES OF NORTH DAKOTA, MONTANA, WASHINGTON AND ALASKA. NUMEROUS SMALL LANDSLIDES WERE OBSERVED IN THE EPICENTRAL REGION. SEE FIGURE 8.
033	1985/12/23	19:37	62.065	124.291	5.6	10.	MACKENZIE MOUNTAINS, N.W.T. AFTERSHOCK. FELT AT WRIGLEY, FORT SIMPSON, NAHANNI BUTTE AND FORT LIARD, N.W.T.
034	1985/12/25	15:42	62.018	124.183	5.3	10.	MACKENZIE MOUNTAINS, N.W.T. AFTERSHOCK. FELT AT WRIGLEY, FORT SIMPSON, NAHANNI BUTTE AND FORT LIARD, N.W.T. ALSO FELT IN THE SOUTHERN YUKON, NORTHERN ALBERTA, NORTHERN BRITISH COLUMBIA AND AT YAKUTAT, ALASKA.
035	1985/12/25	18:49	61.970	124.282	5.3	10.	MACKENZIE MOUNTAINS, N.W.T. AFTERSHOCK. FELT AT WRIGLRY, FORT SIMPSON, NAHANNI BUTTE AND FORT LIARD, N.W.T.
055	1986/07/08	05:15	48.269	122.563	3.4	64.	WASHINGTON. FELT (V) AT LYMAN; (IV) AT COUPEVILLE, FREELAND, HAMILTON, MUKILTEO, OAK HARBOR AND SILVANA; (III) AT BURLINGTON, LA CONNER, MOUNT VERNON AND SHAW ISLAND; (II) AT LAKE STEVENS. ALSO FELT AT ALGER, ARLINGTON, CONCRETE, GREENBANK, LEDGEWOOD BEACH AND MARYSVILLE, WASHINGTON, AND VICTORIA, B.C.
056	1986/07/10	16:00	49.597	122.462	3.5	5.	NEAR PITT LAKE, B.C. FELT AT BURNABY, PORT COQUITLAM, NORTH VANCOUVER AND VANCOUVER.
057	1986/07/12	20:31	46.111	68.220	3.4	9.	NEW BRUNSWICK-MAINE BORDER. FELT AT HOULTON, MAINE. ALSO FELT AT NEW LIMERICK, LUDLOW AND DREW LAKE, ME. AND HARTLAND, N. B.
058	1986/07/28	15:26	45.460	74.540	2.6	18.	WESTERN QUEBEC. FELT IN RIGAUD
059	1986/07/29	00:40	47.570	70.230	2.6	14.	CHARLEVOIX REGION, QUE. FELT IN ST-HILARION
060	1986/07/29	00:51	47.570	70.210	2.2	12.	CHARLEVOIX REGION, QUE. FELT IN ST-HILARION
061	1986/08/06	11:18	46.370	75.220	3.5	18.	WESTERN QUEBEC. FELT IN MONT-LAURIER AND MANIWAKI, QUE
062	1986/08/13	04:55	45.104	74.255	3.3	7.	SOUTHWESTERN QUEBEC. FELT (IV) IN HUNTINGDON, COTEAU STATION, QUE., AND CORNWALL, ONT. FELT INTENSITY (III) IN VALLEYFIELD, QUE. FELT IN MALONE, MASSENA OGDENSBURG AND MORIA OF NORTHERN N.Y. RESIDENTS AWAKENED IN HUNTINGDON, QUE. (IV). LOUD NOISE LASTING FEW SECONDS IN COTEAU STATION, QUE. (III), HOUSES WERE SHAKEN. WEAK SHAKING IN VALLEYFIELD, QUE.(III) NOISE AT END OF TREMOR. IN CORNWALL, ONT. (IV), TREMOR LASTED 10-20 SECONDS. REPORT OF HOUSE CREAKING, AND OF OBJECTS RATTLING
063	1986/09/19	15:53	47.300	70.320	4.2	22.	CHARLEVOIX REGION, QUE. FELT AT LA POCATIERE, LA MALBAIE, BAIE-ST-PAUL, ILE-AUX-COUDRES, ST-JOSEPH-DE-LA-RIVE, ST-HILARION, AND ST-IRENEE WIDELY FELT IN THE QUEBEC CITY AREA (IV) NEAR QUEBEC CITY, IN CHARLESBOURG, BOISCHATEL, STE-BRIGITTE DE LAVAL AND ST-ROMUALD, QUE., PEOPLE REPORTED VIBRATING WINDOWS,
064	1986/09/24	11:04	46.700	65.880	2.3	18.	MIRAMICHI REGION, N.B. FELT BY TWO PEOPLE NEAR BLACKVILLE
065	1986/10/17	14:47	47.000	66.600	4.1	5.	MIRAMICHI REGION, N.B. FELT IN BATHURST
066	1986/10/28	16:47	47.000	66.600	3.4	5.	MIRAMICHI REGION, N.B. FELT IN BATHURST
067	1986/11/07	10:35	48.120	123.317	2.9	38.	NEAR PORT ANGELES, WASHINGTON. FELT IN THE JAMES BAY AREA OF VICTORIA, B.C.
068	1986/11/09	19:57	49.235	67.409	4.2	18.	LOWER ST. LAWRENCE VALLEY, QUE. FELT ON THE NORTH SHORE OF THE ST.LAWRENCE AT RAGUENAU, BAIE-COMEAU, GODBOUT, BAIE-TRINITE, SEPT-ILES, QUE. ON THE SOUTH SHORE FROM MATANE TO CAP-CHAT, QUE.
069	1986/11/29	18:00	49.579	120.526	3.0	5.	SOUTHEASTERN BRITISH COLUMBIA FELT MILDLY NORTH OF PRINCETON

Table 2. Earthquakes felt in Canada, January 1985 to December 1986.

No.	Date	Time	Lat° N	Long° W	Mag	Depth	LOCATION AND COMMENTS
001	1985/01/09	19:27	60.294	140.717	5.7	15.	YUKON-ALASKA BORDER. FELT
002	1985/01/29	06:03	79.730	0.320	5.0	18.	GREENLAND SEA
003	1985/02/20	03:15	79.640	3.640	4.2	10.	GREENLAND SEA
004	1985/03/23	11:57	49.110	128.520	4.4	10.	WEST OF VANCOUVER ISLAND
005	1985/03/30	08:44	73.250	71.270	4.7	18.	BAFFIN BAY
006	1985/04/04	06:36	54.070	133.440	4.2	18.	QUEEN CHARLOTTE ISLANDS
007	1985/04/26	04:40	51.090	131.560	4.0	10.	WEST OF VANCOUVER ISLAND
008	1985/05/09	04:08	62.213	141.287	4.3	2.	YUKON-ALASKA BORDER. FELT
009	1985/05/18	13:10	81.850	3.800	4.8	10.	GREENLAND SEA
010	1985/06/14	06:19	81.240	5.100	4.5	10.	GREENLAND SEA
011	1985/06/24	17:46	47.560	128.880	4.0	10.	WEST OF VANCOUVER ISLAND
012	1985/07/25	17:41	83.950	2.700	4.9	10.	GREENLAND SEA
013	1985/07/25	17:45	84.040	0.920	4.8	10.	GREENLAND SEA
014	1985/07/25	17:48	83.740	1.880	4.5	10.	GREENLAND SEA
015	1985/08/02	13:40	60.139	140.998	4.4	8.	YUKON-ALASKA BORDER
016	1985/08/06	03:01	50.750	130.460	4.2	10.	WEST OF VANCOUVER ISLAND
017	1985/08/06	13:53	49.250	116.840	4.0	18.	SOUTHERN BRITISH COLUMBIA. FELT
018	1985/08/07	14:28	50.740	130.500	4.2	10.	WEST OF VANCOUVER ISLAND
019	1985/08/10	02:35	48.950	128.220	4.4	10.	WEST OF VANCOUVER ISLAND
020	1985/08/31	06:57	60.120	140.940	4.4	10.	YUKON-ALASKA BORDER
021	1985/09/10	08:30	47.780	128.750	4.5	10.	WEST OF VANCOUVER ISLAND
022	1985/09/15	01:28	59.133	136.554	5.4	2.	SOUTHEASTERN ALASKA. FELT
023	1985/09/30	23:08	50.800	130.410	4.2	18.	WEST OF VANCOUVER ISLAND
024	1985/10/05	15:24	62.208	124.217	6.6	6.	MACKENZIE MOUNTAINS, N.W.T. FELT WIDELY
025	1985/10/05	15:57	62.190	124.240	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
026	1985/10/05	16:00	62.190	124.240	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
027	1985/10/05	17:30	61.858	124.174	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
028	1985/10/05	17:32	62.214	124.345	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
029	1985/10/05	18:14	62.058	124.285	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
030	1985/10/05	19:07	62.010	124.261	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
031	1985/10/05	19:13	62.062	124.272	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
032	1985/10/05	19:41	62.105	124.259	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
033	1985/10/06	01:15	62.058	124.292	5.0	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
034	1985/10/06	01:22	62.035	124.257	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
035	1985/10/06	02:16	61.965	124.228	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
036	1985/10/06	12:52	79.930	114.820	4.8	18.	ARCTIC OCEAN
037	1985/10/06	14:00	62.032	124.252	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
038	1985/10/09	16:28	62.276	124.353	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
039	1985/10/10	08:52	62.108	124.192	4.5	10.	MACKENZIE MOUNTAINS, N.W.T.
040	1985/10/12	21:11	62.211	124.400	4.4	10.	MACKENZIE MOUNTAINS, N.W.T.
041	1985/10/12	21:13	62.300	124.387	4.5	10.	MACKENZIE MOUNTAINS, N.W.T.
087	1986/01/01	04:36	62.006	124.159	4.8	10.	MACKENZIE MOUNTAINS, N.W.T.
088	1986/01/05	06:55	62.041	124.331	4.4	10.	MACKENZIE MOUNTAINS, N.W.T.
089	1986/01/05	14:28	62.032	124.212	4.4	10.	MACKENZIE MOUNTAINS, N.W.T.
090	1986/01/06	00:02	49.290	129.610	4.4	10.	WEST OF VANCOUVER ISLAND
091	1986/01/07	12:25	62.021	124.234	4.4	10.	MACKENZIE MOUNTAINS, N.W.T.
092	1986/01/08	02:00	57.290	58.160	4.3	18.	LABRADOR SEA
093	1986/01/10	11:07	85.690	7.600	4.6	18.	GREENLAND SEA
094	1986/01/11	13:29	47.710	70.120	4.0	5.	CHARLEVOIX REGION, QUE. FELT
095	1986/01/11	21:54	62.143	124.254	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
096	1986/01/30	06:05	62.228	124.332	4.6	10.	MACKENZIE MOUNTAINS, N.W.T.
097	1986/01/31	16:45	41.700	81.180	5.0	5.	PAINESVILLE, OHIO NEAR CLEVELAND. FELT WIDELY
098	1986/02/05	07:21	62.008	124.178	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
099	1986/02/09	06:08	82.670	7.990	4.7	10.	GREENLAND SEA
100	1986/02/11	21:54	62.033	124.292	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
101	1986/02/13	20:36	62.103	124.212	5.4	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
102	1986/02/16	02:46	66.520	135.420	4.8	18.	NORTHERN YUKON TERRITORY. FELT
103	1986/02/17	12:46	62.109	124.257	4.7	10.	MACKENZIE MOUNTAINS, N.W.T.
104	1986/02/20	15:21	62.136	124.224	4.4	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
105	1986/03/02	09:01	62.007	124.155	4.6	10.	MACKENZIE MOUNTAINS, N.W.T.
106	1986/03/02	12:57	61.980	124.226	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
107	1986/03/12	05:36	62.087	124.289	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
108	1986/03/18	08:08	63.920	126.830	4.4	18.	MACKENZIE MOUNTAINS, N.W.T.
109	1986/03/21	08:14	62.053	124.218	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
110	1986/03/21	23:55	54.240	122.000	5.4	10.	EASTERN BRITISH COLUMBIA. WIDELY FELT
111	1986/03/26	00:99	49.180	127.660	4.3	10.	WEST OF VANCOUVER ISLAND
112	1986/04/05	11:50	76.422	107.089	4.0	18.	QUEEN ELIZABETH ISLANDS, N.W.T.
113	1986/04/12	19:35	57.702	53.519	4.4	18.	LABRADOR SEA
114	1986/04/20	09:59	57.384	59.509	4.8	18.	LABRADOR SEA. FELT
115	1986/04/22	17:21	72.210	130.320	5.0	30.	BEAUFORT SEA
116	1986/04/26	17:12	50.370	130.070	4.4	10.	WEST OF VANCOUVER ISLAND
117	1986/05/02	22:33	62.092	124.242	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
118	1986/05/03	15:35	66.142	141.185	4.3	18.	YUKON-ALASKA BORDER
119	1986/05/03	23:05	62.152	124.193	4.9	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
120	1986/05/18	04:08	62.322	124.264	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
121	1986/05/21	02:13	65.271	140.955	4.4	18.	YUKON-ALASKA BORDER
122	1986/05/21	03:18	80.728	120.079	4.6	18.	ARCTIC OCEAN
123	1986/05/21	23:27	60.295	140.618	4.8	18.	YUKON-ALASKA BORDER
124	1986/05/22	17:21	72.190	130.120	4.5	18.	BEAUFORT SEA
125	1986/05/24	14:30	66.794	93.492	4.0	18.	KEEWATIN DISTRICT, N.W.T.
126	1986/06/06	05:21	71.987	136.127	4.1	18.	BEAUFORT SEA

Tableau 2. (cont.)

042	1985/10/12	21:15	62.190	124.240	4.6	10.	MACKENZIE MOUNTAINS, N.W.T.
043	1985/10/13	04:22	61.978	124.264	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
044	1985/10/13	17:16	62.320	124.211	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
045	1985/10/14	23:19	62.093	124.263	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
046	1985/10/16	12:53	50.950	130.290	4.2	10.	WEST OF VANCOUVER ISLAND
047	1985/10/16	18:44	62.108	124.341	4.5	10.	MACKENZIE MOUNTAINS, N.W.T.
048	1985/10/19	10:06	41.110	73.920	4.1	18.	CENTRAL U.S.A.
049	1985/10/21	12:41	62.054	124.321	4.8	10.	MACKENZIE MOUNTAINS, N.W.T.
050	1985/10/24	23:13	53.820	131.500	4.1	18.	QUEEN CHARLOTTE ISLANDS
051	1985/10/27	01:39	49.280	127.910	4.7	10.	WEST OF VANCOUVER ISLAND
052	1985/10/28	14:03	60.195	141.176	4.1	0.	MACKENZIE MOUNTAINS, N.W.T.
053	1985/11/09	04:46	62.247	124.263	4.6	10.	MACKENZIE MOUNTAINS, N.W.T.
054	1985/11/12	08:49	71.410	136.700	4.3	18.	BEAUFORT SEA
055	1985/11/12	14:49	62.197	124.412	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
056	1985/11/16	07:10	58.970	136.750	4.6	18.	SOUTHEASTERN ALASKA
057	1985/11/24	19:29	62.070	124.218	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
058	1985/12/05	01:26	60.660	60.140	4.2	18.	LABRADOR SEA
059	1985/12/07	15:29	62.212	124.389	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
060	1985/12/15	12:42	50.980	134.030	4.7	10.	WEST OF VANCOUVER ISLAND
061	1985/12/23	05:15	62.187	124.243	6.9	10.	MACKENZIE MOUNTAINS, N.W.T. FELT WIDELY
062	1985/12/23	05:26	62.190	124.240	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
063	1985/12/23	05:26	62.190	124.240	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
064	1985/12/23	05:48	62.140	124.380	5.2	10.	MACKENZIE MOUNTAINS, N.W.T.
065	1985/12/23	06:02	62.006	124.522	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
066	1985/12/23	06:05	61.944	124.552	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
067	1985/12/23	06:11	62.119	124.836	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
068	1985/12/23	08:09	62.186	124.228	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
069	1985/12/23	09:37	61.966	124.271	4.8	10.	MACKENZIE MOUNTAINS, N.W.T.
070	1985/12/23	11:26	62.243	124.393	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
071	1985/12/24	11:39	79.780	94.390	4.5	18.	AXEL HEIBERG ISLAND, N.W.T.
072	1985/12/24	16:52	62.271	124.416	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
073	1985/12/25	19:37	62.065	124.291	5.6	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
074	1985/12/23	22:11	62.022	124.253	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
075	1985/12/23	23:22	62.000	124.409	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
076	1985/12/24	07:40	61.976	124.336	4.6	10.	MACKENZIE MOUNTAINS, N.W.T.
077	1985/12/24	20:01	62.026	124.287	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
078	1985/12/25	00:16	62.127	124.214	4.1	10.	MACKENZIE MOUNTAINS, N.W.T.
079	1985/12/25	15:42	62.018	124.183	5.3	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
080	1985/12/25	16:08	62.028	124.356	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
081	1985/12/25	16:20	61.978	124.267	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
082	1985/12/25	18:49	61.970	124.282	5.3	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
083	1985/12/26	00:02	62.099	124.476	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
084	1985/12/26	22:58	62.050	124.342	4.4	10.	MACKENZIE MOUNTAINS, N.W.T.
085	1985/12/29	19:15	62.126	124.301	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
086	1985/12/30	18:55	62.033	124.127	4.8	10.	MACKENZIE MOUNTAINS, N.W.T.
127	1986/06/06	14:47	50.180	130.211	4.5	10.	WEST OF VANCOUVER ISLAND
128	1986/06/14	18:38	49.031	128.732	4.2	10.	WEST OF VANCOUVER ISLAND
129	1986/06/15	02:02	62.235	124.299	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
130	1986/06/16	15:54	49.431	127.017	5.2	35.	OFF WEST COAST OF VANCOUVER ISLAND. FELT WIDELY
131	1986/07/04	08:54	62.157	124.248	4.8	10.	MACKENZIE MOUNTAINS, N.W.T. FELT
132	1986/07/27	08:16	60.243	129.383	4.3	18.	SOUTHEAST YUKON
133	1986/08/07	06:14	49.313	129.163	4.1	10.	WEST OF VANCOUVER ISLAND
134	1986/08/12	12:39	62.044	124.313	4.4	10.	MACKENZIE MOUNTAINS, N.W.T.
135	1986/08/16	09:51	62.296	124.359	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
136	1986/08/20	18:53	61.770	124.324	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
137	1986/08/20	22:47	60.266	141.072	4.1	12.	YUKON-ALASKA BORDER
138	1986/08/27	14:11	58.992	142.866	4.5	30.	GULF OF ALASKA
139	1986/08/28	11:46	62.222	124.241	4.2	10.	MACKENZIE MOUNTAINS, N.W.T.
140	1986/09/07	00:21	60.134	143.471	4.2	18.	YUKON-ALASKA BORDER
141	1986/09/12	17:40	60.784	57.237	4.2	18.	LABRADOR SEA
142	1986/09/15	14:47	61.518	143.862	4.7	52.	SOUTHERN ALASKA.
143	1986/09/19	15:53	47.300	70.320	4.2	22.	CHARLEVOIX REGION, QUE. FELT
144	1986/09/24	06:03	54.374	54.998	4.5	18.	LABRADOR SEA
145	1986/09/26	21:04	48.832	129.121	4.3	10.	WEST OF VANCOUVER ISLAND
146	1986/09/29	13:01	83.170	22.860	4.1	18.	GREENLAND SEA
147	1986/10/11	22:25	48.782	128.138	4.5	10.	WEST OF VANCOUVER ISLAND
148	1986/10/11	22:53	48.821	128.304	4.2	10.	WEST OF VANCOUVER ISLAND
149	1986/10/13	02:25	62.665	143.364	4.3	18.	MACKENZIE MOUNTAINS, N.W.T.
150	1986/10/17	14:47	47.000	66.600	4.1	5.	MIRAMICHI REGION, N.B. FELT
151	1986/10/25	14:55	79.553	97.580	4.5	18.	ARCTIC OCEAN
152	1986/11/09	02:16	60.157	140.943	4.3	12.	YUKON-ALASKA BORDER
153	1986/11/09	19:57	49.235	67.409	4.2	18.	LOWER ST. LAWRENCE RIVER, QUE. FELT
154	1986/11/10	13:32	62.089	124.376	4.3	10.	MACKENZIE MOUNTAINS, N.W.T.
155	1986/11/11	13:12	47.586	129.292	4.3	10.	WEST OF VANCOUVER ISLAND
156	1986/11/11	13:13	73.737	86.517	4.4	18.	EASTERN PART OF BRODEUR POINT, BAFFIN ISLAND, N.W.T.
157	1986/12/01	16:16	61.439	140.320	4.2	10.	YUKON-ALASKA BORDER
158	1986/12/01	18:00	61.454	140.343	4.2	10.	YUKON-ALASKA BORDER
159	1986/12/03	05:34	49.657	129.882	4.5	10.	WEST OF VANCOUVER ISLAND
160	1986/12/03	05:45	49.705	129.862	4.7	10.	WEST OF VANCOUVER ISLAND
161	1986/12/03	16:56	49.634	129.766	4.3	10.	WEST OF VANCOUVER ISLAND
162	1986/12/03	17:46	49.588	129.811	4.1	10.	WEST OF VANCOUVER ISLAND
163	1986/12/03	21:26	49.642	129.779	4.8	10.	WEST OF VANCOUVER ISLAND
164	1986/12/03	21:49	49.642	129.801	4.0	10.	WEST OF VANCOUVER ISLAND
165	1986/12/06	05:32	50.069	130.152	4.6	10.	WEST OF VANCOUVER ISLAND
166	1986/12/06	21:04	51.111	130.582	4.5	18.	WEST OF VANCOUVER ISLAND
167	1986/12/07	16:17	62.043	124.347	4.0	10.	MACKENZIE MOUNTAINS, N.W.T.
168	1986/12/17	09:46	78.944	20.638	5.0	18.	GREENLAND
169	1986/12/21	17:45	60.099	140.976	4.2	11.	YUKON-ALASKA BORDER

Table 2 does not list some earthquakes which were located and felt in areas adjacent to Canada but were not reported felt in Canada. Table 2 also does not list some mining-induced tremors in eastern Canada that were felt in communities surrounding the mines.

A more detailed description of the seismic activity for each region of Canada is given in the following sections. More than three thousand earthquakes were located in Canada during this two-year period. However, this report only lists the larger events; the smaller events with magnitudes less than 4.0 are not tabulated here but are shown on the maps.

EASTERN CANADA

Eastern Canada is generally a stable continental region and as a consequence has a low rate of earthquake activity. However, large earthquakes have occurred here in the past, notably in the Charlevoix Region of Quebec in 1925, off the Atlantic coast south of Newfoundland in 1929, in the Lake Temiscaming region along the Ontario-Quebec border in 1935 and near Cornwall, Ontario in 1944. For 1985-86, 644 events are plotted on the eastern region map (Fig. 4). Prince Edward Island had no earthquake activity located in it during these two years; Nova Scotia had only two small events.

Ontario

In 1985-86, the earthquake activity was largely confined to the Ottawa Valley area of eastern Ontario, with isolated events in the Lake Erie-Lake Ontario Basin and northern Ontario. The northwestern part of Ontario is shown on the Central Region map. The largest earthquake affecting eastern Canada was the magnitude 5.0 event on 31 January 1986 located on the south shore of Lake Erie. This tremor was felt throughout southern Ontario (Fig. 5) and caused isolated minor property damage and some minor injuries in Ohio (Stover, 1986; Cajka and Stevens, 1986). It was also widely felt in north-central U.S.A.

Many of the small events shown in northern Ontario in the Sudbury, Kirkland Lake, Elliot Lake and Red Lake areas are mining-related rockbursts.

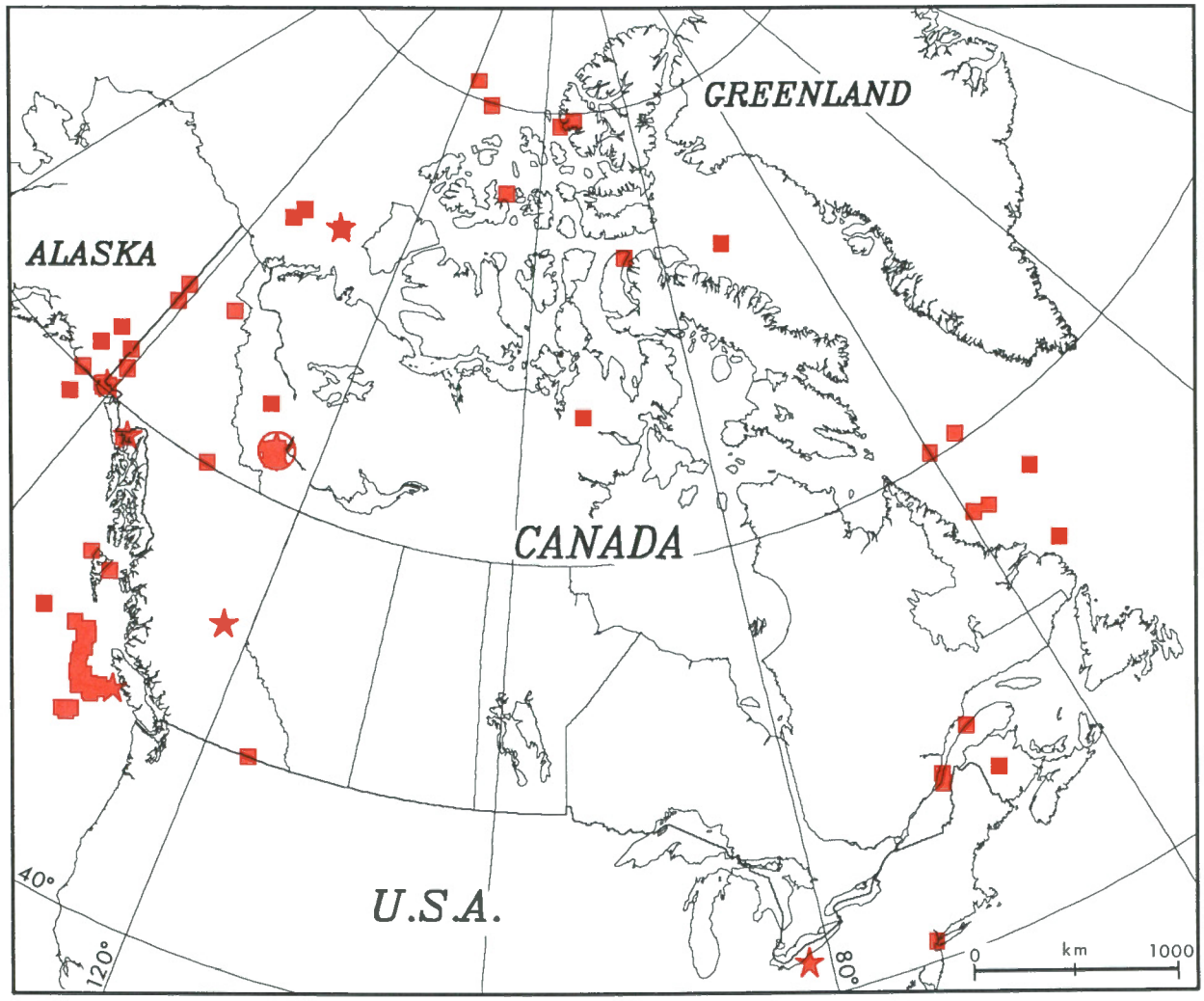

Figure 3. Earthquake activity (magnitude 4 or greater) in Canada and its environs in 1985-86. See Figure 4 for legend.

Quebec

The earthquake activity in Quebec occurred in three distinct seismic zones: west Quebec (WQU), Charlevoix (CHV) and lower St. Lawrence (LSL). Only scattered and isolated activity occurred outside these three active zones, except for the cluster of small magnitude events visible to the east of James Bay (BJ). These events were likely induced seismicity at the Baie James Hydroelectric Project.

The largest events were two magnitude 4 earthquakes that occurred in the Charlevoix zone on 11 January and 19 September 1986 and one magnitude 4 event that occurred in the Lower St. Lawrence zone on 9 November 1986. All three tremors were strongly felt in the areas surrounding the epicentres, but caused no property damage (Table 2).

No earthquakes in the west Quebec zone had magnitude 4.0 or greater in 1985-86, although a number of smaller events were reported felt by local residents (Table 2).

New Brunswick

Scattered small magnitude earthquake activity was recorded throughout New Brunswick during this period, with a continuing series of earthquakes in the Miramichi region (MIR) of central New Brunswick at the site of a large magnitude 5.7 event that occurred there in 1982. The largest earthquake in the province in 1985-86, magnitude 4.1, occurred at the Miramichi zone on 17 October 1986 and was felt mildly throughout the province. More than 75 small aftershocks were recorded by the closest seismograph station (about 25 km distance) in the three days following the tremor. However, by the end of October this activity had subsided.

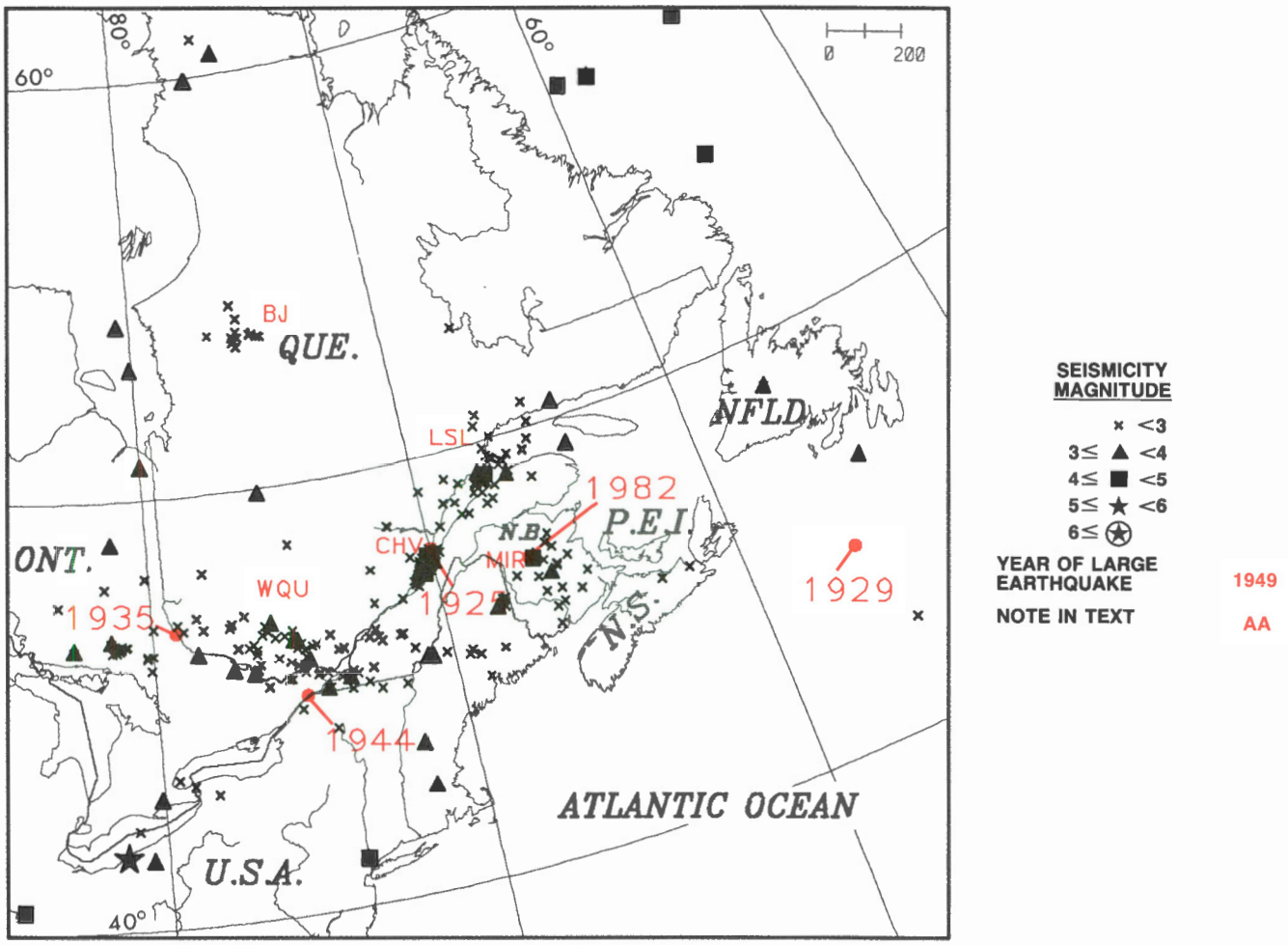

Figure 4. Earthquakes in eastern Canada for 1985-86. BJ is the Baie James Hydroelectric Project, WQU is the west Quebec seismic zone, CHV is the Charlevoix seismic zone, LSL is the lower St. Lawrence seismic zone and MIR is the Miramichi seismic zone. Location and year of significant earthquakes in this century in the region are indicated.

Newfoundland and Labrador

Three small earthquakes were recorded in central Newfoundland at the town of Buchans in January and March 1985. Two of the tremors were felt by residents in Buchans (17 January and 22 March 1985). It is believed that these events were rockbursts in the Buchans mine, but this could not be confirmed because the mine had been closed and flooded during the previous year and could not be inspected.

Offshore areas

Four magnitude 4 earthquakes were detected in the Labrador Sea, and a few smaller events were detected there and in the Grand Banks area south of Newfoundland. One of these events was felt onshore, at Nain, Labrador on 20 April 1985.

CENTRAL CANADA

This region is characterized by an extremely low rate of earthquake activity; it is probably one of the most stable areas in the world. In the past most earthquakes in this region have occurred in southern Saskatchewan and adjacent areas of Montana and North Dakota. The largest earthquake known in this region occurred in 1909 with a magnitude of 5.5. For 1985-86, 14 events are plotted on Figure 6. Manitoba had no earthquake activity located in it during this two-year period. There was one magnitude 3 event detected in northern Ontario near the Manitoba border (Fig. 6) where no earthquake activity had been known previously.

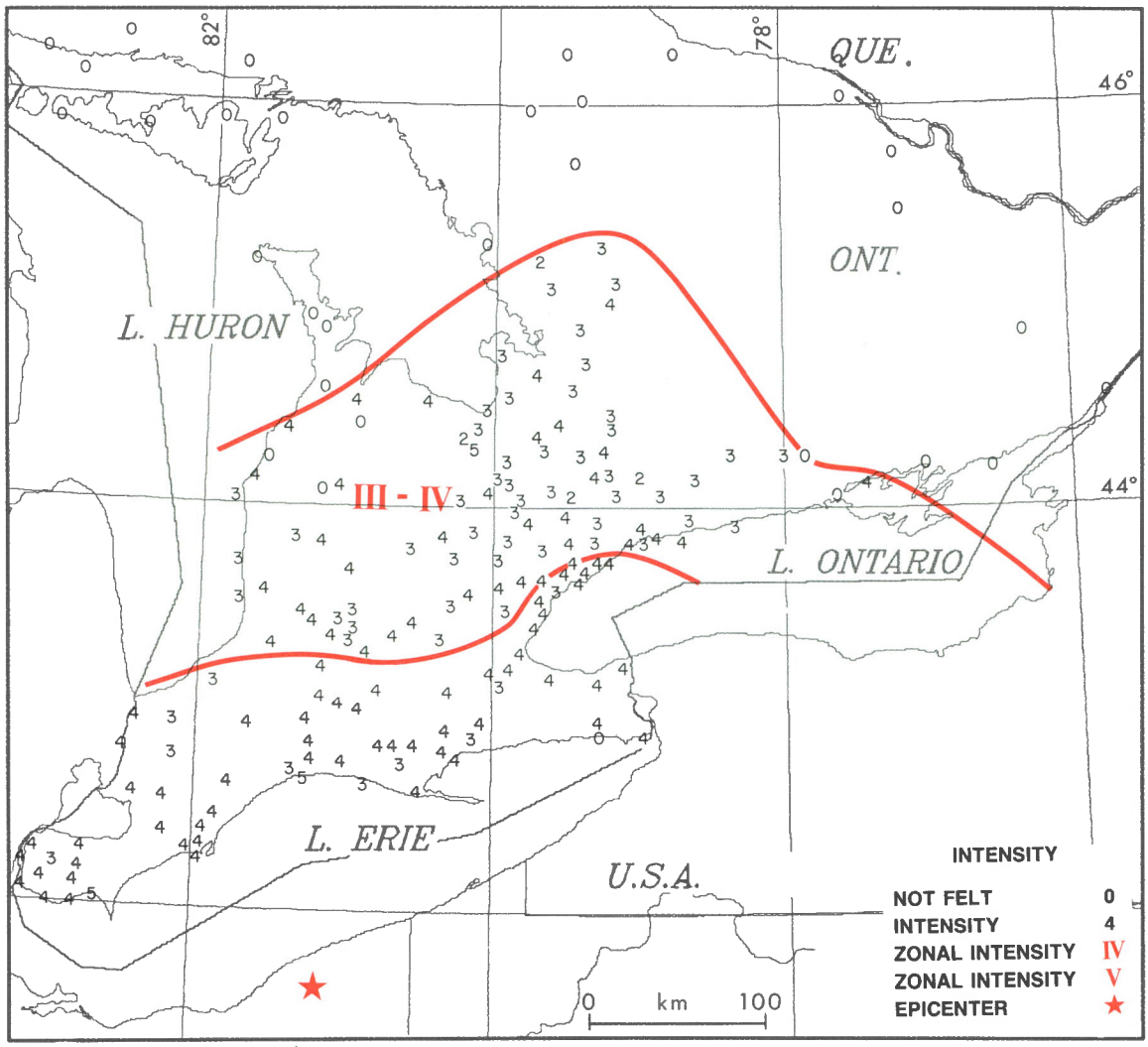

Figure 5. Felt reports and isoseismal distribution in southern Ontario for the 31 January 1986 earthquake near Painesville, Ohio.

Saskatchewan

Only four events were detected in the province. The largest, magnitude 3 and located near the Manitoba-Saskatchewan border, was probably related to potash mining near Esterhazy. Two other smaller events, which were also probably mining-related, were detected, one near Esterhazy and one near Saskatoon.

WESTERN CANADA

Most of the earthquake activity in this region is related to the North American-Pacific plate interactions which are most obvious in the offshore areas. However, a high rate of earthquake activity is also experienced on Vancouver Island and the B.C. lower mainland. Large earthquakes occurred on central Vancouver Island in 1918 and 1946, in southern Puget Sound (Washington State) in 1949 and 1965, and south of the Queen Charlotte Islands in 1929 and 1970. In 1949 Canada's largest earthquake, and one of the world's great earthquakes, occurred along the western coast of the Queen Charlotte Islands. It had a magnitude of 8.1 and was felt throughout British Columbia and as far away as western Alberta. Other strong earthquakes have occurred farther north along the southeastern Alaska coast in 1958 and 1972 and near the B.C.-Alberta border in 1918. For 1985-86 2112 events are plotted on Figure 7.

Alberta

Earthquake activity in Alberta was confined to the western part of the province. No events with magnitude 4.0 or greater occurred in the province during this two-year period. Three magnitude 3 events and a number of smaller events were located in close proximity to gas-producing plants west of Rocky Mountain House and were felt locally. They were probably related to the gas-recovery processes.

Residents of northern and west-central Alberta, including Edmonton, felt three earthquakes located some distance outside the province in 1985-86. The first two were the

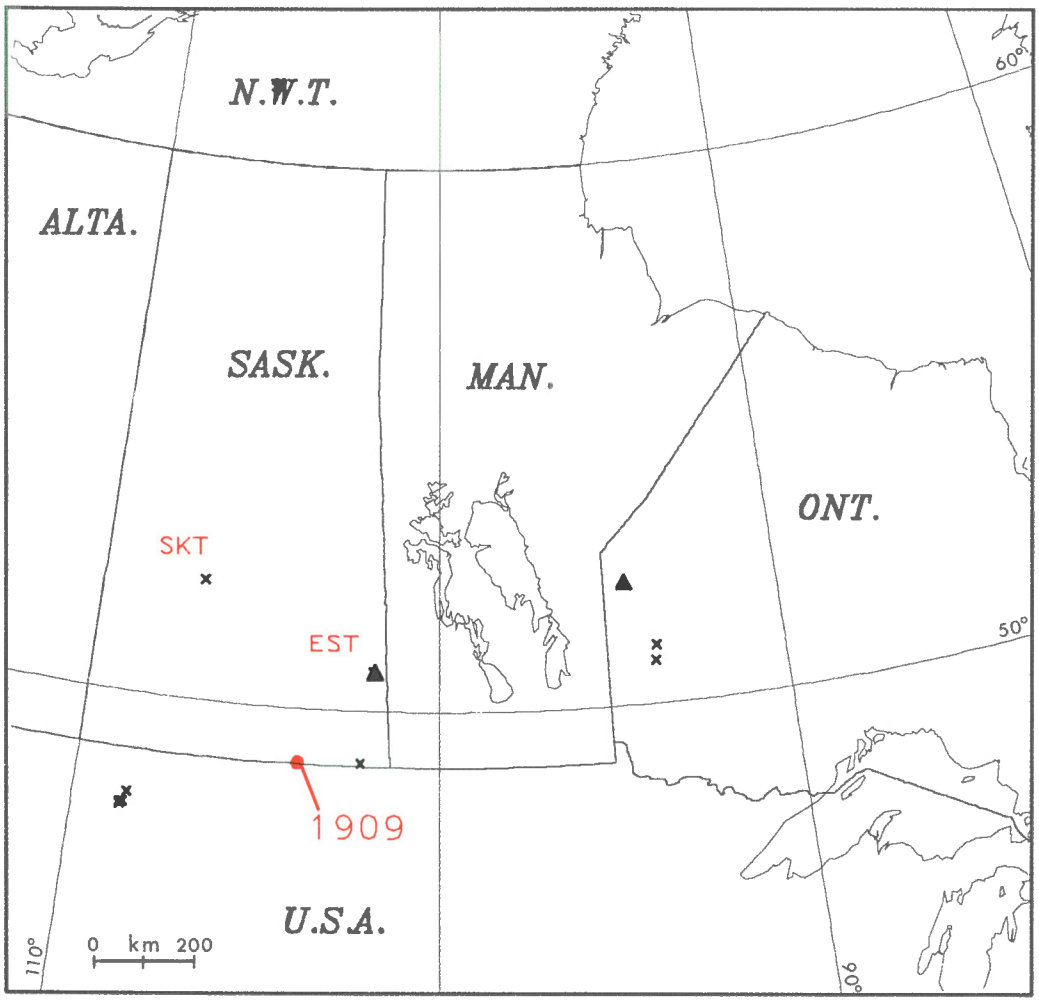

Figure 6. Earthquakes in central Canada in 1985-86. SKT is Saskatoon and EST is Esterhazy. Location of the largest earthquake in the region in 1909 is shown. See Figure 4 for legend.

Nahanni, N.W.T. earthquakes of 5 October and 23 December 1985 which were strongly felt in northern and north-central Alberta (Fig. 8); the third tremor was the Prince George, B.C. earthquake of 21 March 1986, which was mildly felt in extreme west-central Alberta.

British Columbia

Vancouver Island

The earthquake activity on southern Vancouver Island (Fig. 9) is the result of underthrusting of the Pacific Ocean crust from the west (Juan de Fuca plate) under the continental crust (North American plate) to the east. This affects southern Vancouver Island, Georgia Strait, the Gulf Islands and the B.C. lower mainland in Canada and the Olympic Peninsula, Puget Sound, the San Juan Islands and northwestern Washington in the U.S. with a high rate of small magnitude earthquake activity and the potential for large damaging earthquakes. However, in this two-year period only events with magnitude less than 4.0 occurred onshore in this region and none was widely felt.

The strongest earthquake, magnitude 5.2, occurred on 23 March 1986 just off the west coast of north-central Vancouver Island. This tremor was widely felt (Fig. 10), but caused no property damage. It was the strongest of many earthquakes which took place on the active fault zone running from Nootka Island on the northern Vancouver Island coastline to the active tectonic features farther offshore. The Nootka zone represents the boundary between the Juan de Fuca and Explorer crustal plates in this area.

Queen Charlotte Islands

Most of the earthquake activity, including several events of magnitude 4, occurred off the west coast of the islands on the active Queen Charlotte Islands Fault, which was the location of the magnitude 8.1 earthquake in 1949. Clusters of small magnitude activity occurred at several spots along the western coasts of the islands and off the eastern coast of Graham Island in Hecate Strait (Fig. 11).

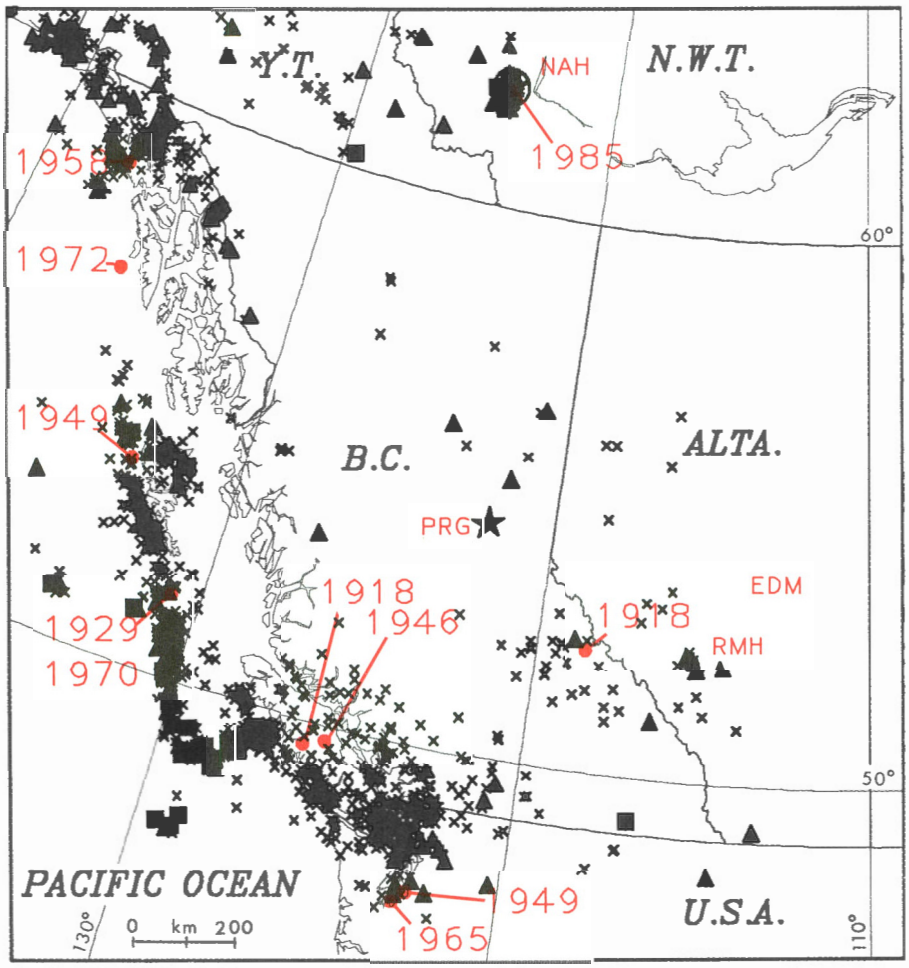

Figure 7. Earthquakes of western Canada in 1985-86. PRG indicates the Prince George earthquake, RMH is the Rocky Mountain House seismic zone, EDM shows the location of the city of Edmonton and NAH is the Nahanni seismic zone. Location and year of the significant earthquakes in this century in the region are indicated. See Figure 4 for legend.

Earthquake activity on the islands was minor during 1985-86 with one event of magnitude 4.0 being located inland of the Queen Charlotte Fault. On northern Graham Island two magnitude 3 earthquakes were felt. They were located in a zone of frequent earthquake activity which has been detected by improved monitoring in this area in recent years.

B.C. interior

The largest earthquake in 1985-86, magnitude 5.4, occurred in the area near Prince George on 21 March 1986. This earthquake was widely felt in central British Columbia (Fig. 12) and caused minor property damage close to the epicentre (Rogers et al., 1988). Otherwise, only scattered earthquake activity was seen in British Columbia interior, particularly in the southern Rocky Mountains, with one other magnitude 4 event which was located near the U.S. border in the southeastern part of the region on 8 August 1985 (Fig. 7) and was felt locally.

Offshore areas

The earthquake activity of the western offshore areas between Vancouver Island and the Queen Charlotte Islands was intense and dominated by the long linear zone of seismic activity which follows a sequence of active plate boundary features in this region (Fig. 7). These active features (Sovanco Fracture Zone, Explorer Ridge, Dellwood Knolls) mark the present boundary of the Pacific and North American crustal plates in this region. Twenty-seven events with magnitude 4.0 and greater occurred in this general region in 1985-86. None were felt.

NORTHERN CANADA

Northern Canada has active faults along the Fairweather-Yakutat zone in the southwestern part of the Yukon Territory with a correspondingly high rate of earthquake activity. Four great earthquakes, magnitude 8.0 or greater, occurred in this area in a space of 13 months in 1899-1900. Other

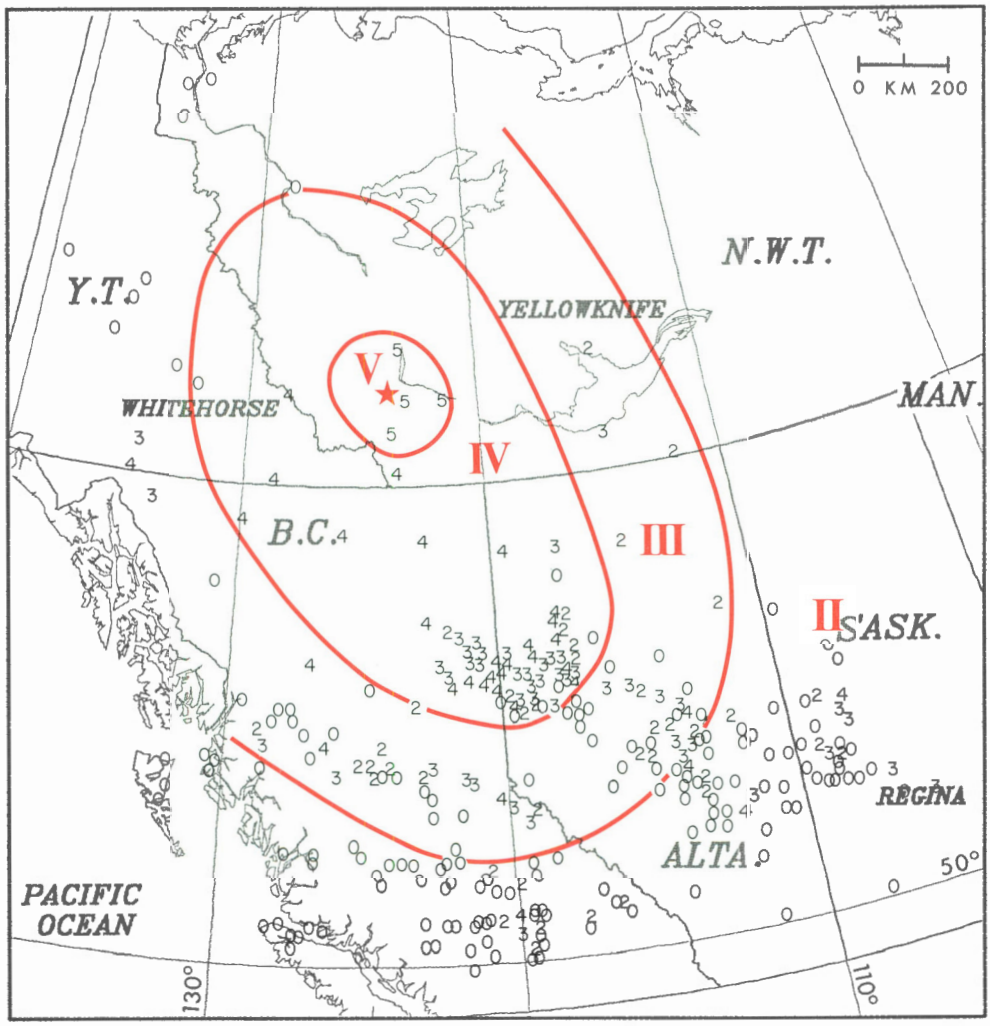

Figure 8a. Felt reports and isoseismal distribution for the 5 October Nahanni earthquake. See Figure 5 for legend.

strong earthquakes have occurred in the southern Yukon in 1944 and in the northern Yukon in 1940 and 1955. The Northwest Territories, by contrast, are part of a large generally stable region of the North American plate without active plate boundary features and have a correspondingly low rate of earthquake activity. Nevertheless, pockets of significant earthquake activity do occur in several parts of the Northwest Territories and the largest earthquake known above the Arctic Circle, magnitude 7.3, occurred in Baffin Bay in 1933. Strong earthquakes also occurred in the Baffin region in 1945, 1957 and 1963 and in the Beaufort Sea in 1920.

The active plate boundary between the North American and Asian plates is located at the Arctic Mid-Ocean Ridge northeast of Greenland and a higher rate of earthquake activity occurs there. Some of the larger earthquakes on this feature and the adjacent areas of northern Greenland are noted in this section because they record well on northern Canadian seismograph stations even though they do not affect the Canadian landmass directly. In all, 1370 events are plotted (Fig. 13), but most of these are in the Yukon. Because of the wider spacing of the seismograph stations in the Northwest Territories, earthquakes with magnitudes less than 3.0 can not be routinely detected there.

Yukon Territory

The earthquake activity of the southwestern Yukon is frequent and there is a history of large magnitude events. This area marks a transition from the active strike-slip faults along the coast of southeastern Alaska to the south to the active thrust faults of the Aleutian Trench farther to the west. A total of 1131 events are plotted on Figure 14. However, several hundreds were aftershocks to the Nahanni earthquakes located in the western Northwest Territories, which are described in the next section.

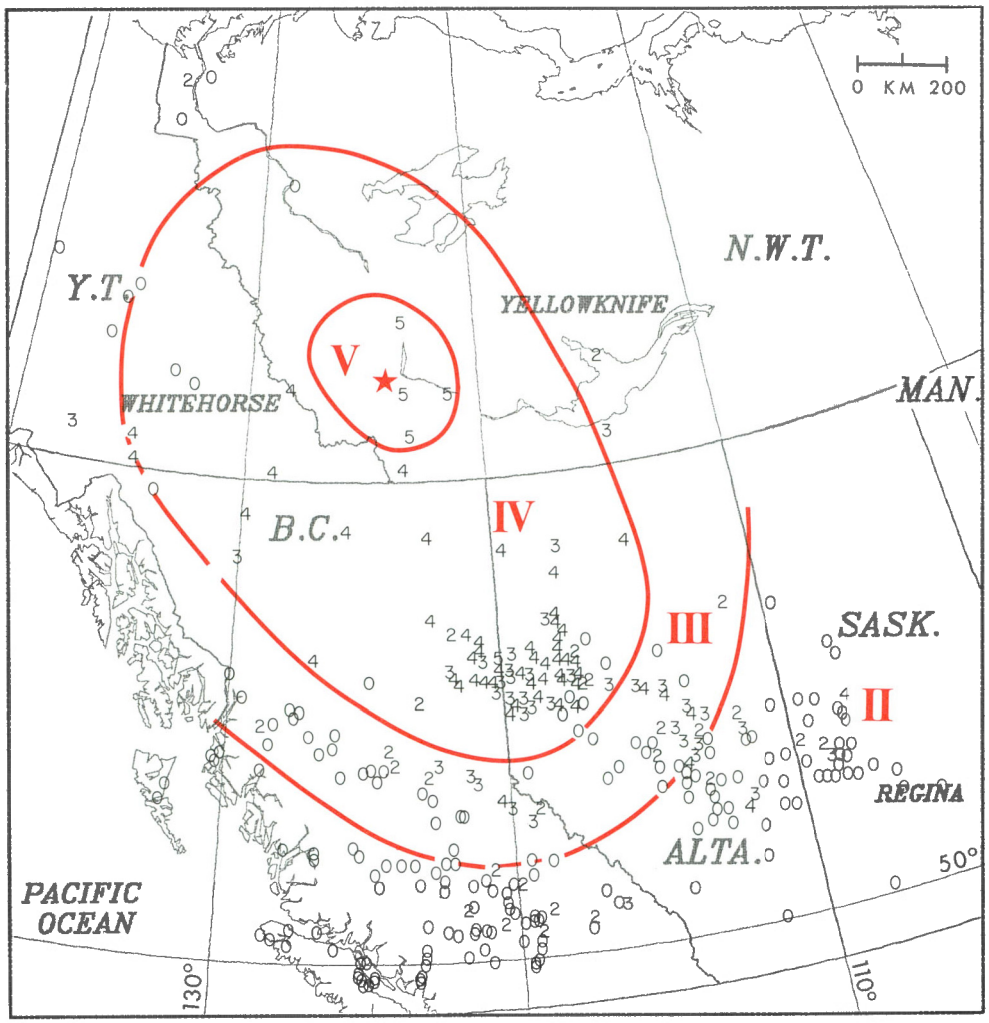

Figure 8b. Felt reports and isoseismal distribution for the 23 December 1985 Nahanni earthquake. See Figure 5 for legend.

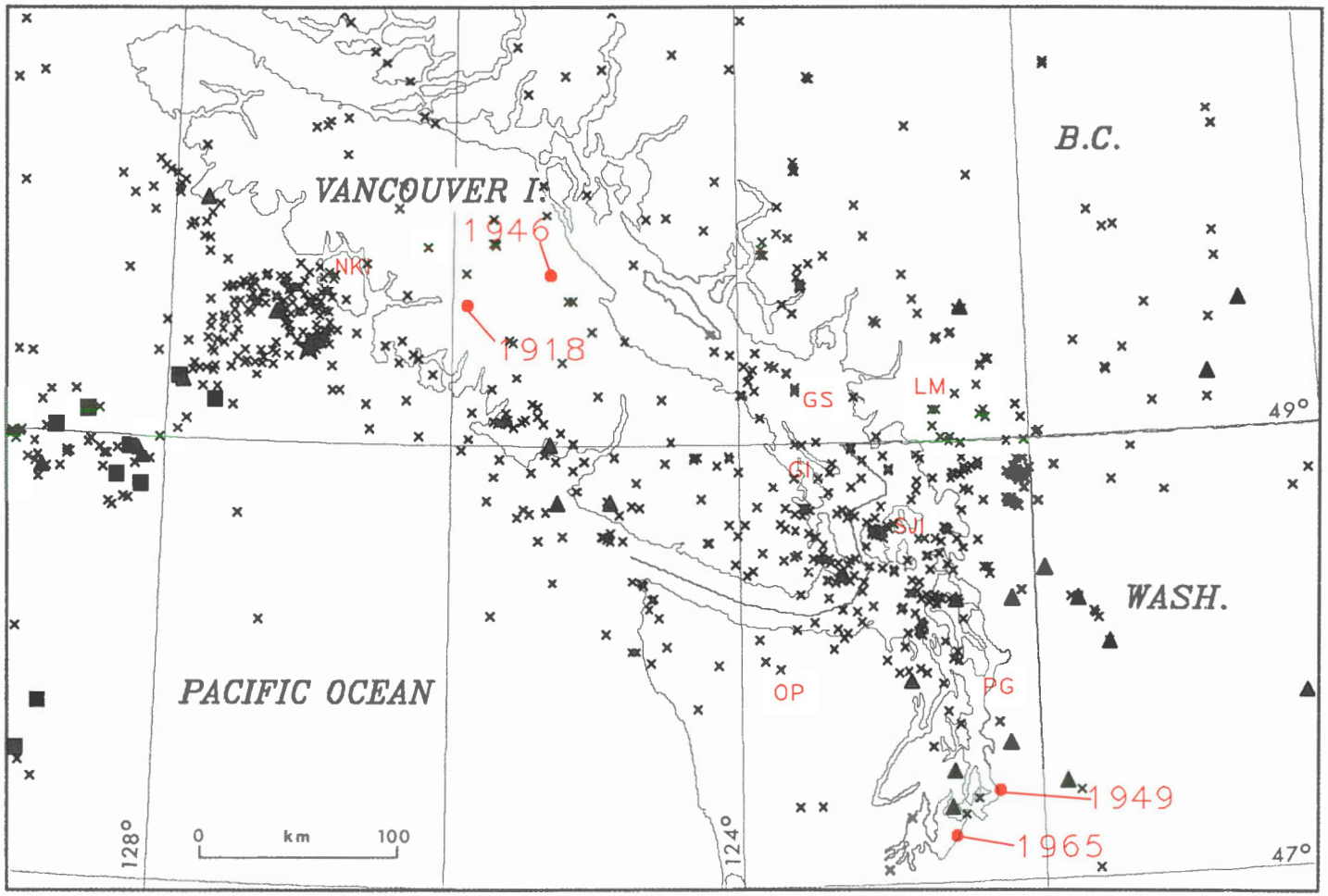

Figure 9. Earthquake activity on Vancouver Island and the B.C. lower mainland. NKI is Nootka Island, GI are the Gulf Islands, SJI are the San Juan Islands, LM is the B.C. lower mainland, OP is the Olympic Peninsula and PG is Puget Sound. Location and year of the more significant earthquakes in this century in the region are indicated. See Figure 4 for legend.

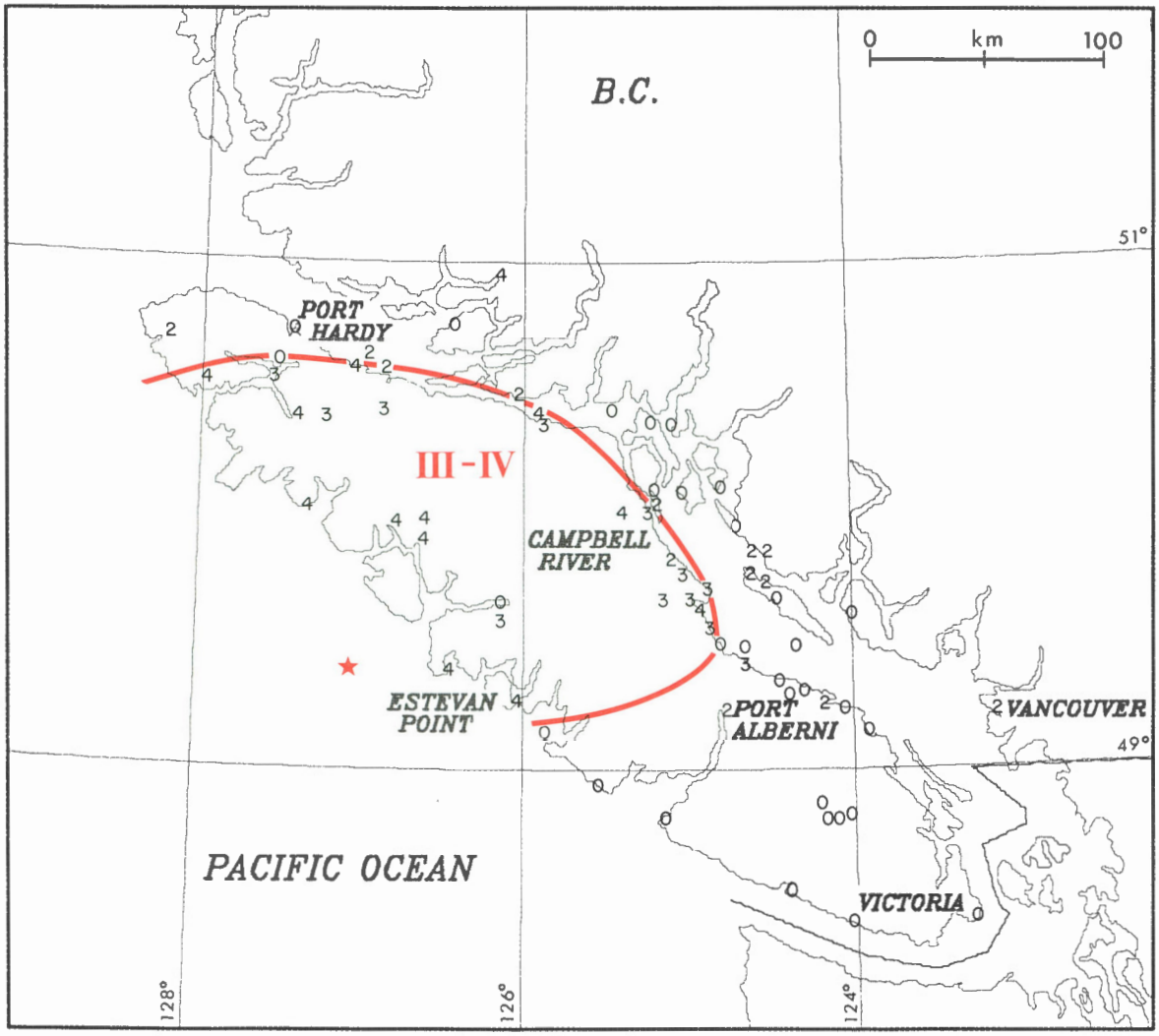

Figure 10. Felt reports for the 16 June 1986 earthquake off Estevan Point, B.C. See Figure 5 for legend.

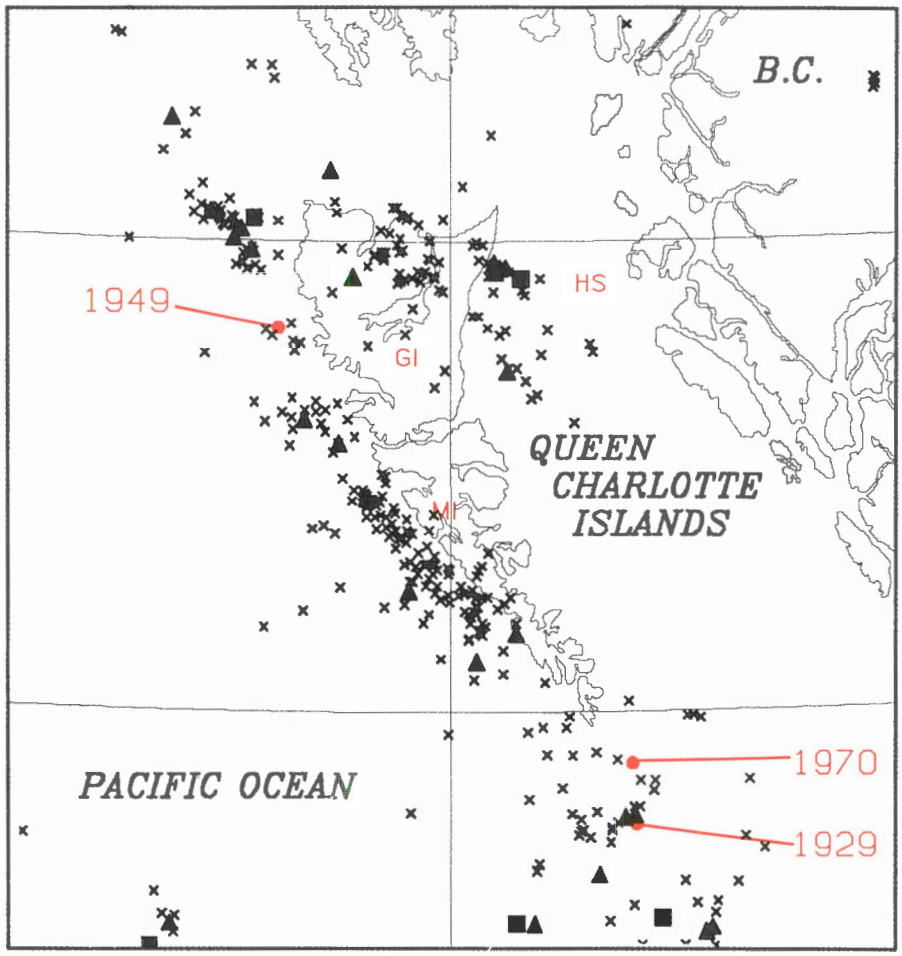

Figure 11. Earthquake activity on the Queen Charlotte Islands in 1985-86. GI is Graham Island, MI is Moresby Island and HS is Hecate Strait. Location and year of the larger earthquakes this century in the region are shown. See Figure 4 for legend.

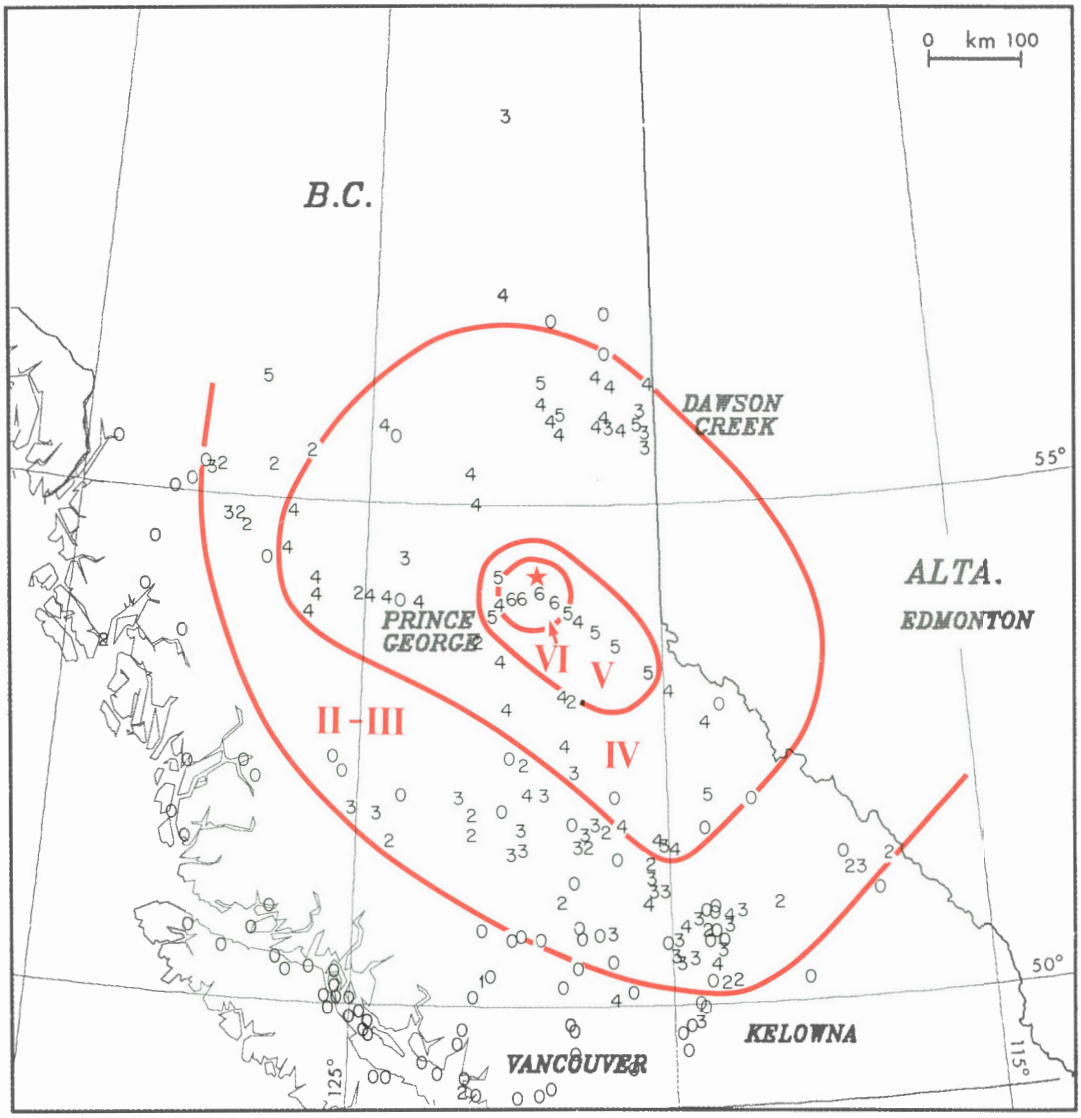

Figure 12. Felt reports and isoseismal intensity for the 21 March 1986 Prince George earthquake. See Figure 5 for legend.

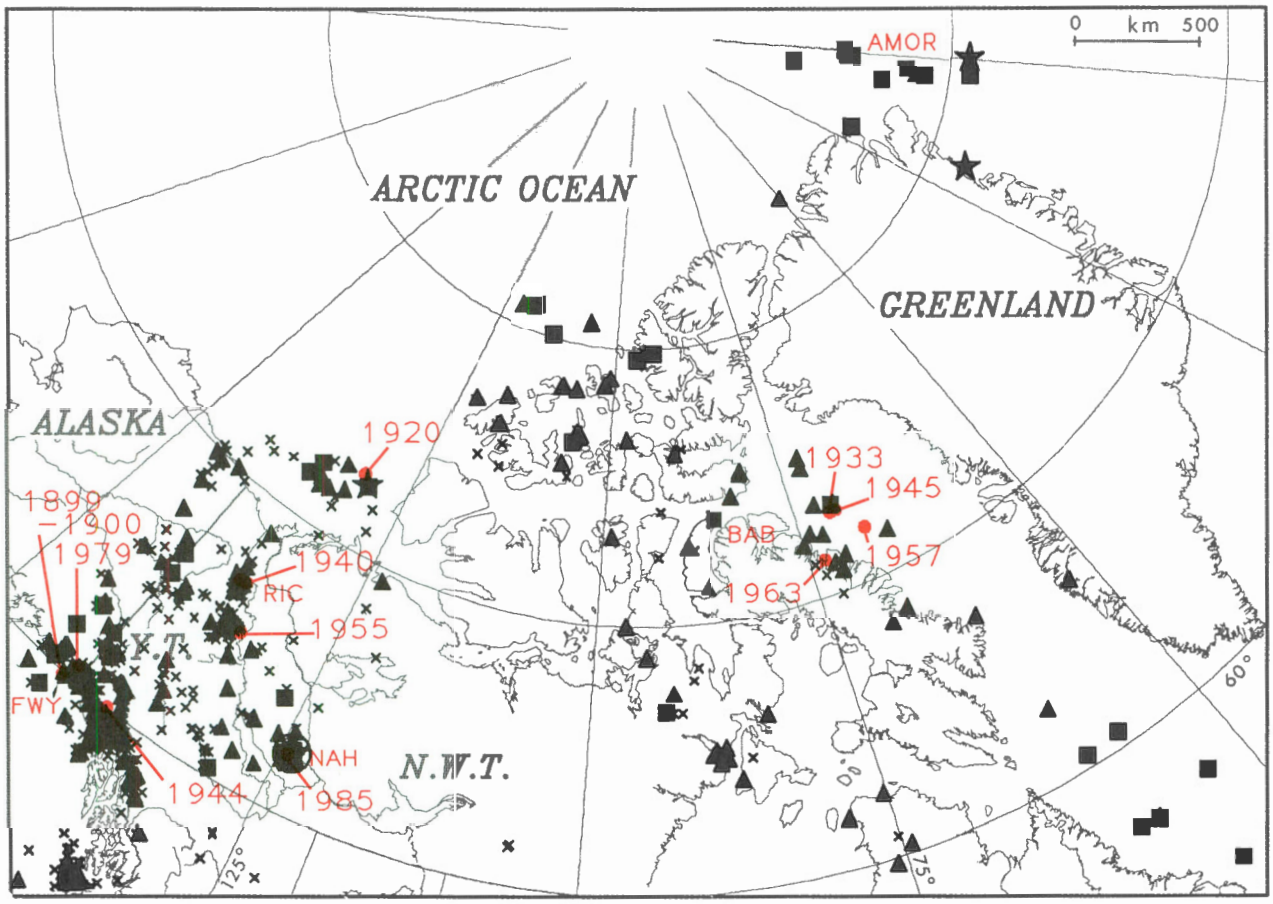

Figure 13. Earthquakes in northern Canada in 1985-86. FWY is the Fairweather fault zone, RIC is the Richardson Mountains seismic zone, NAH is the Nahanni seismic zone, BAB is the Baffin Bay seismic zone and AMOR is the Arctic Mid-Ocean Ridge system. The location and year of the larger earthquakes this century are shown. See Figure 4 for legend.

The seismic activity in the Yukon is arranged generally in four zones parallel to the west coast. The first zone follows the Fairweather-Yakutat faults (FWY) along the coast and the St. Elias Mountains. This zone has produced some large earthquakes. The most recent was the 1979 magnitude 7.5 St. Elias earthquake; frequent aftershock activity is still occurring at the site of this earthquake on the extreme southwestern corner of the Yukon. Inland of the FWY zone is a distinct linear zone of earthquake activity along the active Denali fault system (DFS). Northeast of the Denali fault in the interior of the Yukon is a diffuse zone of of earthquake activity associated generally with the Tintina Trench and the Olgivie Mountains (T-O). Finally in northeastern Yukon along the border with the N.W.T. is a zone of frequent activity associated with the Richardson Mountains (RIC).

The largest events in this area during 1985-86 were a magnitude 5.7 event in the Fairweather zone on 9 January 1985 and a magnitude 5.4 event on 15 September 1985 at the southeastern end of the Denali zone on the border of British Columbia and Alaska. Both events were felt locally; neither caused any property damage.

Northwest Territories

Mackenzie Valley

Canada's largest earthquakes in 1985-86, and largest in the Northwest Territories since 1963, were in this area on 5 October and 23 December 1985. These two events, magnitude 6.6 and 6.9 respectively, occurred near the North Nahanni River (NAH) in the Mackenzie Mountains of the western Northwest Territories. Both were widely felt (Fig. 8) including many parts of British Columbia and Alberta to the south of the epicentres. A number of interesting studies of these earthquakes have been carried out, including those by Wetmiller et al. (1987, 1988), Weichert et al. (1986a,b), Evans et al. (1986) and Boatwright and Choy (1988). Perhaps the most noteworthy of the effects of the earthquakes documented in these studies are the occurrence with the October event of the fourth largest landslide known in Canada this century and, for the December event, the strongest near-field seismic accelerations (>2g) ever recorded for an earthquake.

The aftershock sequences which followed these two large events were intense, and included at least 78 aftershocks magnitude 4.0 and greater and 8 magnitude 5.0 and greater. The largest aftershock was magnitude 5.7, on 25 December 1985. Many of the larger aftershocks were felt in the closest communities such as Wrigley and Fort Simpson, but caused no damage.

Earthquakes with magnitude less than 5.0 occurred elsewhere in the western Northwest Territories in 1985-86. A magnitude 4.8 event, located in the Richardson Mountains (RIC) of the northern Yukon on 16 February 1986, was reported felt in communities in the Mackenzie delta area such as Fort McPherson and Inuvik. Strong earthquakes occurred in the RIC zone in 1940 and 1955.

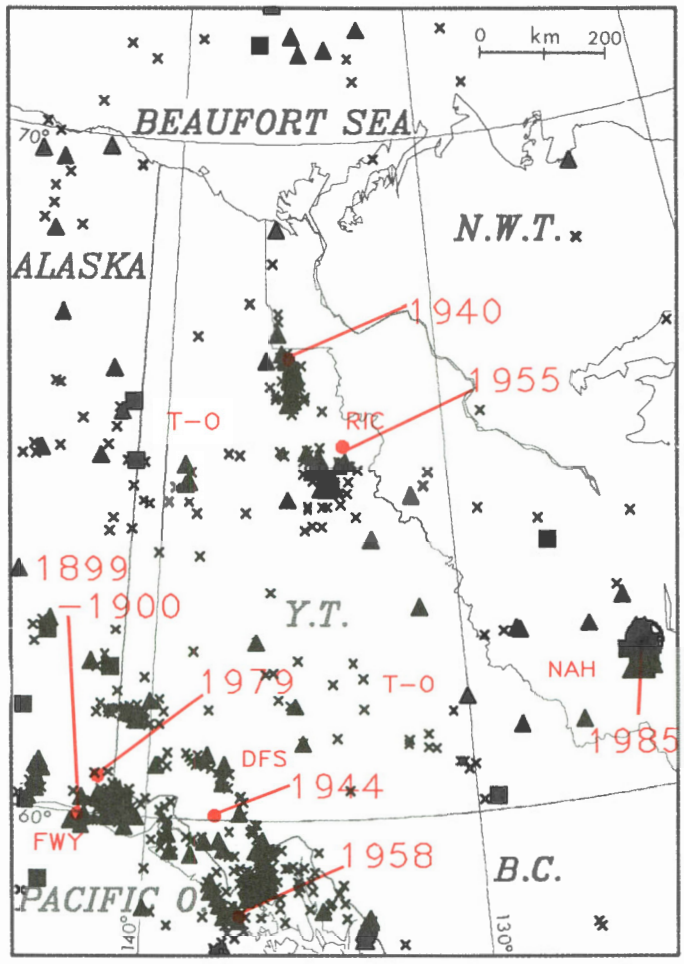

Figure 14. Earthquakes in the Yukon Territory in 1985-86. FWY is the Fairweather fault zone, DFS is the Denali fault zone, T-O is the Tintina-Ogilvie seismic zone, RIC is the Richardson Mountains seismic zone and NAH is the Nahanni seismic zone. See Figure 4 for legend.

Arctic Islands and Greenland

A number of earthquakes with magnitudes less than 5.0 occurred on or near Baffin, Melville, Prince Patrick, Ellef Ringnes, Devon, Bathurst and Axel Heiberg Islands in 1985-86. None were reported felt.

A magnitude 5.0 earthquake was detected on the east coast of Greenland on 17 December 1986.

Beaufort Sea, Arctic Ocean and Baffin Bay

Earthquake activity occurred in all these offshore areas in 1985-86. The largest events were a magnitude 5.0 earthquake in the Beaufort Sea on 22 April 1986 and a magnitude 5.0 event on 29 January 1985 in the Greenland Sea part of the Arctic Ocean off northern Greenland, where it was part of the trend of seismic activity related to the Arctic Mid-Ocean Ridge (AMOR), the active plate boundary feature between North America and Asia. Ten events magnitude 4.0 or greater were detected in this region during 1985-86.

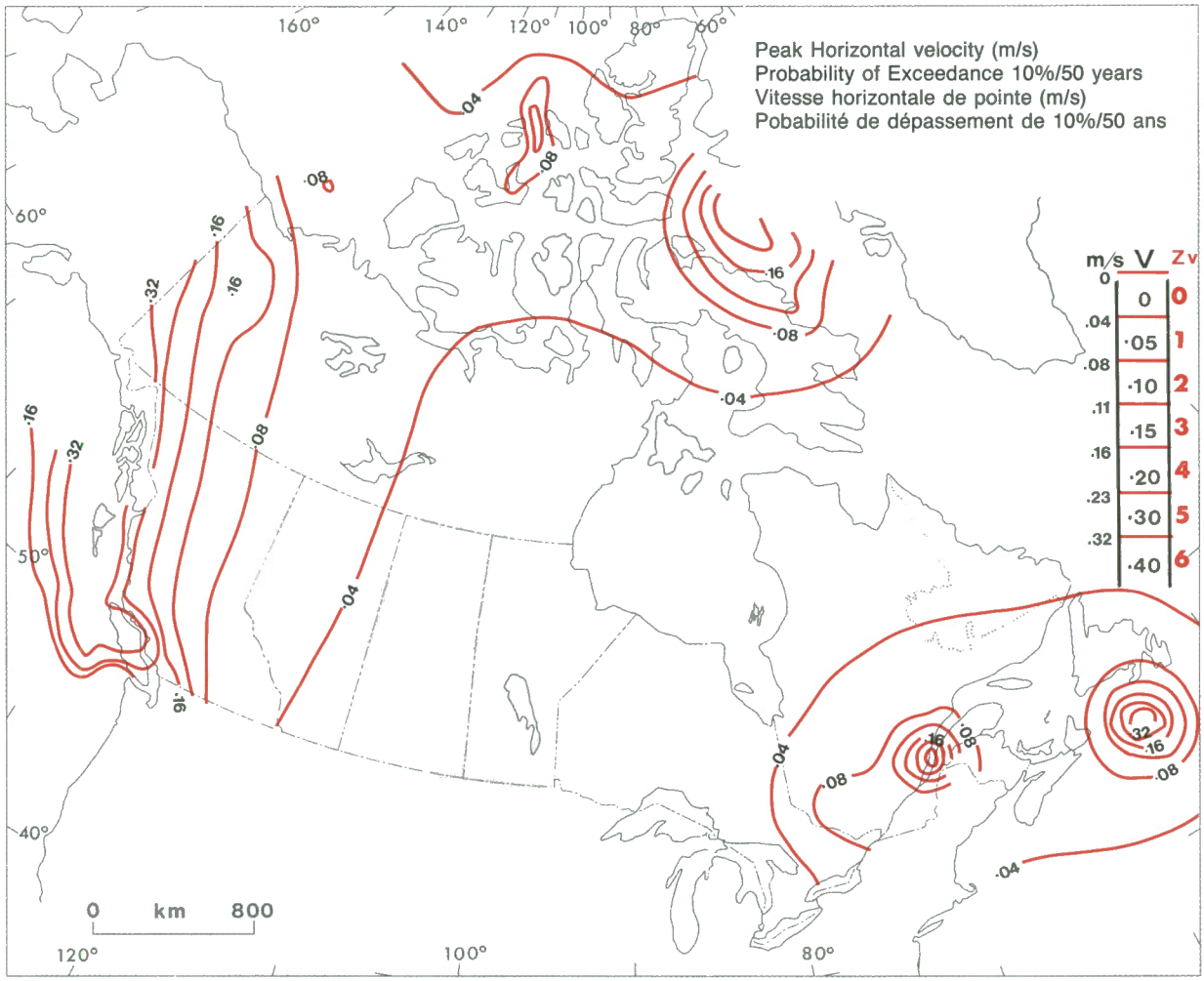

Figure 15. Seismic hazard zoning map from the 1985 National Building Code of Canada. Zv is the seismic zone number.

EARTHQUAKE HAZARDS IN CANADA

The descriptions of seismic activity given above show that earthquake activity affects almost all parts of Canada and that large, potentially destructive earthquakes have occurred several times in Canadian territory this century. The fact that none of these large earthquakes has resulted in a social disaster with extensive property damage and many casualties has been more due to good luck than to any special properties of the earthquakes or to Canada's position in the world of plate tectonics. Large earthquakes will occur again in Canada and one of them, if it occurs in a densely populated region, could potentially be the largest single natural disaster this country will ever face.

The relative level of long-term hazard due to earthquakes across Canada is quantified for the National Building Code of Canada (NBCC) in terms of seismic ground motion values which have a small probability of being exceeded in a given time period; for the NBCC parameters of 10 % in 50 years are used to define the seismic zones. The map shown here (Fig. 15) is the current zoning map from the 1985 NBCC. It divides the country into zones of equal earthquake hazard: seven zones from 0 to 6. The higher zones, which include parts of the British Columbia coast, the southwestern Yukon, part of the lower St. Lawrence valley in Quebec and two areas off the east coast of Canada, are the areas where stronger earthquake effects are likely to occur. People who live in or near these areas should be prepared to deal with the effects of strong earthquakes. The lower zones have correspondingly less risk of earthquakes, but they still may experience strong earthquakes only less frequently than the higher zones.

Seismologists cannot predict when the next strong earthquake will occur in Canada. It is most likely to occur in one of the zone 6 regions, but not necessarily. The two strongest earthquakes in 1985-86, the magnitude 6.6 and 6.9 Nahanni earthquakes in October and December 1985, occurred in an area of the Northwest Territories which is in seismic zone 1 of the NBCC map.

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APPENDIX

Significant Canadian earthquakes in this century

1899-1900: Four great earthquakes (M about 8) occurred along the southeast Alaska coast in the 13-month period from September 1899 to October 1900. Major topographic changes were made to the Alaska coast by these earthquakes and strong effects were experienced in many parts of northern British Columbia and southern Yukon.

1909: A moderate earthquake (M5.5) shook the central plains of southern Saskatchewan on 16 May. Isolated minor property damage from the event was reported in several localities.

1918: A strong earthquake (M6) occurred on 4 February in the southern Rocky Mountains of eastern British Columbia

1918: A major earthquake (M7) occurred on 6 December on west-central Vancouver Island near Estevan Point.

1920: A strong earthquake (M6.5) occurred on 16 November in the Beaufort Sea.

1925: A strong earthquake (M6.5-7.0)occurred in the Charlevoix area of Quebec on 1 March. The earthquake damaged most of the houses in the epicentral area and caused considerable damage in Quebec City.

1929: A major earthquake (M7) occurred in the Pacific Ocean just south of the Queen Charlotte Islands on 26 May.

1929: A major earthquake (M7) occurred in the Atlantic Ocean south of Newfoundland on 18 November. The earthquake generated a tsunami on the south coast of Newfoundland which killed 27 people and caused a large underwater landslide which broke 12 trans-Atlantic telegraph cables. The tremor was felt over a wide area of eastern North America.

1933: The largest earthquake known north of the Arctic Circle (M7.3) occurred in Baffin Bay on 20 November.

1935: A strong earthquake (M6.3) occurred on 1 November in the Lake Temiscaming area along the Ontario-Quebec border. Chimneys were knocked down in Mattawa and North Bay. The tremor was felt over much of eastern Canada.

1940: Two strong earthquakes (M6.2 and 6.5) occurred in the Richardson Mountains of the northern Yukon on 29 May and 5 June.

1944: A strong earthquake (M6.5) occurred in the Denali Fault Zone west of Whitehorse, Yukon on 3 February.

1944: A moderate earthquake (M5.7) occurred near Cornwall, Ontario on 5 September. Many homes in Cornwall were damaged by the tremor and property damage from the event totaled two million dollars in Cornwall and the surrounding communities.

1945: A strong earthquake (M6.5) occurred in Baffin Bay on 1 January.

1946: A major earthquake (M7.3) occurred on central Vancouver Island on 23 June. Serious property damage occurred along the east coast of Vancouver Island and one person was drowned.

1949: A major earthquake (M7.1) occurred in the southern Puget Sound area of Washington State on 13 April. The earthquake caused heavy property damage over a wide area of Washington and was strongly felt in Victoria and Vancouver.

1949: Canada's largest earthquake (M8.1) and one of the world's great earthquakes occurred along the west coast of the Queen Charlotte Islands on 22 August. The tremor was felt over a wide area of western North America.

1955: A strong earthquake (M6.6) occurred in the northern Yukon Territory on 1 March.

1957: A strong earthquake (M6.3) occurred in Baffin Bay on 2 May.

1958: A great earthquake (M7.9) occurred along the southeast Alaska coast on 9 July. Several people were killed in Alaska by the tremor, and strong sea-wave and landslide activity was reported. Parts of northwestern British Columbia and the southern Yukon were strongly shaken by the tremor.

1963: A strong earthquake (M6.4) occurred on Baffin Island on 4 September.

1965: A strong earthquake (M6.5) occurred in the southern Puget Sound area of Washington State on 29 April. The tremor caused considerable property damage in Washington and was strongly felt in Vancouver and Victoria.

1970: A major earthquake (M7.0) occurred in the Pacific Ocean south of the Queen Charlotte Islands on 24 June.

1972: A major earthquake (M7.6) occurred along the southeast Alaska coast on 30 July. The tremor caused some property damage in Alaska and was strongly felt over wide areas of northern British Columbia and the southern Yukon.

1979: A major earthquake (M7.5) occurred in the St. Elias Mountains along the Yukon-Alaska border on 28 February. The tremor caused some minor property damage in the Yukon and was widely felt.

1982: A moderate earthquake (M5.7) occurred in the Miramichi Highlands of central New Brunswick on 9 January. The tremor caused isolated minor property damage in several New Brunswick communities.

1985: Two strong earthquakes (M6.6 and 6.9) occurred in the Nahanni region of the Northwest Territories on 5 October and 23 December.