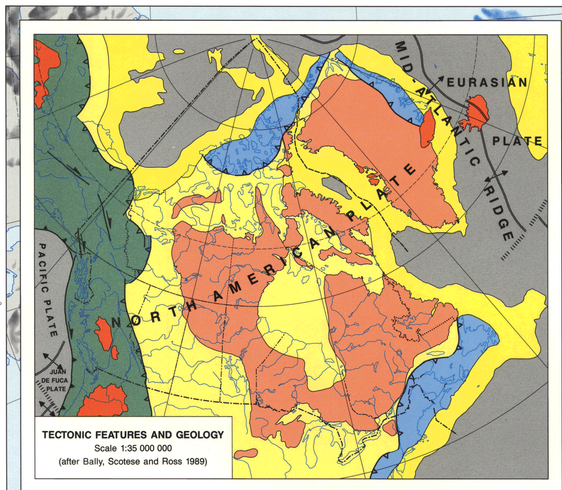
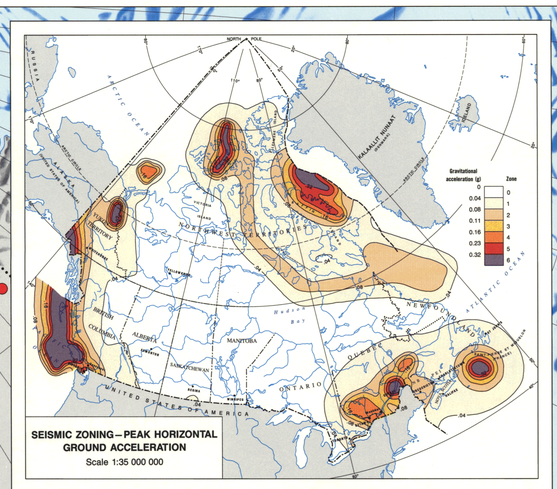


TECTONIC FEATURES AND GEOLOGY
Scale 1:35 000 000
(after Bally, Scotese and Ross 1989)

- Precambrian shield areas
- Platform cover and basins
- Paleozoic folded belts
- Mesozoic-Tertiary folded belts
- Tertiary and Quaternary volcanic rocks
- Passive margins
- Oceanic crust
- Continental strike-slip faults
- Oceanic fracture zones
- Mid-ocean ridges/rift zones
- Subduction boundaries
- Thrust faults at leading edge of folded belts



SEISMIC ZONING – PEAK HORIZONTAL GROUND ACCELERATION
Scale 1:35 000 000

This map shows the distribution of peak horizontal ground acceleration (expressed as a fraction of gravitational acceleration) for seismic wave frequencies of about 5 hertz or oscillations per second. Ground shaking in this frequency range may damage small or rigid structures such as houses and small apartment buildings; the map thus indicates the seismic hazard faced by this type of structure. Acceleration values, and therefore seismic hazard, are lowest in zone 0, highest in zone 6. By providing information on the peak ground motions expected from future earthquakes, seismic zoning maps assist engineers and architects in designing and constructing buildings with safeguards to prevent major loss of life. A second measure, peak horizontal ground velocity at about 1 hertz, is used to indicate the seismic hazard posed to tall, flexible structures such as highrise buildings. The patterns of velocity are similar to those on the acceleration map.

Seismic hazard is traditionally expressed in terms of the likelihood of a given horizontal acceleration or velocity being exceeded during a particular period. In Canada, the probability of exceedence used for seismic zoning maps is 10% over 50 years, meaning that over a 50-year period, there is a 10% chance of an earthquake causing ground motion greater than the expected value given by the map.

This map and the map of peak horizontal velocity were incorporated in the 1985 edition of the National Building Code of Canada. The seismic design provisions of the Code are updated every 10 years to reflect a greater understanding of Canadian seismicity and improvements in the design of earthquake-resistant structures.

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

THE NATIONAL ATLAS OF CANADA 5th EDITION

CANADA
SEISMICITY

Copies of this map may be obtained from the Canada Map Office, Energy, Mines and Resources Canada, Ottawa, or your nearest map dealer. Quote MCR 4171. Printed 1994. ●

Cette carte est aussi publiée en français. Demander le numéro MCR 4171F.

Scale 1:7 500 000 or 1 centimetre represents 75 kilometres
75 0 75 150 225 300 375 450 kilometres

Lambert Conformal Conic Projection, Standard Parallels at 49°N and 77°N.
Modified Polyconic Projection, North of Latitude 80°.

Produced by

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Surveys, Mapping and
Remote Sensing Sector

Geophysics Division
Geological Survey
of Canada

Earthquakes are considered one of the most dangerous of all natural processes known to humans and have resulted in the loss of over one million lives during the 20th century. Each year, over 50 000 events are recorded worldwide. Most earthquakes occur at the boundaries of the very large sections of the earth's crust and upper mantle called tectonic plates. The relative motion of these plates, driven by the internal heat of the earth, is rarely smooth and uniform; it usually takes place in the form of sudden slippage over a portion of the plate boundary when friction is overcome by the inexorable stresses and pressures caused by the shifting plates. This sudden release of energy creates vibrations, or seismic waves, that are felt as an earthquake when they reach the surface. Although earthquakes are considered a natural hazard, the chance of a tremor in certain areas can be increased by human activity such as the filling of large reservoirs, underground mining, and oil and gas production.

More than 1 500 earthquakes are recorded each year in Canada. Most of these measure less than magnitude 3 on the Richter scale and are not felt. Although Canada is not well known for earthquake activity, several important seismic events have occurred in its short written history; for instance, there were 27 deaths due to an earthquake-generated tsunami (large ocean wave) on the south coast of Newfoundland in 1929, and millions of dollars of earthquake damage in Cornwall, Ontario in 1944, on southern Vancouver Island in 1946, and in the Saguenay region of Quebec in 1988. The table appearing on this map lists 24 significant earthquakes that have taken place in or near Canada since 1663. The fact that none of these large events has resulted in social disaster with extensive property damage and heavy casualty is due more to chance than to any special properties of the earthquakes or to Canada's position relative to the world's tectonic plates. Although earthquakes cannot be prevented or as yet predicted, their effects can be mitigated by constructing buildings capable of withstanding the strong ground motion that might occur. Since 1953, the National Building Code of Canada has included earthquake resistance standards and a map of seismic hazard zones (see inset).

This map of seismicity shows the location and magnitude of over 7 900 earthquakes that occurred in or near Canada between 1568 and 1991. Events in foreign areas, for instance parts of Alaska, New England and Greenland, were included so that earthquakes that can potentially affect Canadian territory are represented. To understand the distribution of earthquake activity in Canada, it is necessary to be aware of the location of the tectonic plates whose relative motion causes much of this activity. The simplified tectonic map (inset) provides information on geologic formations and structures that are related to seismicity in Canada.

As mentioned, most earthquakes in the world take place on the major active faults that form tectonic plate boundaries. Events of this kind are termed interplate earthquakes. Three main types of plate boundaries are recognized: rift zones or spreading 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 boundaries are found along the **west coast of Canada** where they represent the interactions of the Pacific and North American plates, which are sliding past each other at a rate of about 6 mm per year, as well as some smaller plates such as the Juan de Fuca Plate, where crust is being both created and destroyed. In the Vancouver Island-Lower Mainland region, seismicity is associated with the subduction of the Juan de Fuca Plate beneath the North American Plate. The Queen Charlotte strike-slip fault off the west coast of the Queen Charlotte Islands has been the site of several major earthquakes, including Canada's largest in 1949. The significant number of events in the southwestern Yukon Territory and adjacent parts of northwestern British Columbia is related to the occurrence of both strike-slip and compressional movements in the area. The presence of active faults offshore makes western Canada subject to more frequent seismic activity and contributes to a higher risk of large damaging earthquakes than other parts of the country. In fact, an earthquake capable of structural damage can be expected to strike somewhere in southwestern British Columbia once every 10 years.

Significant earthquake activity also occurs within the crustal plates, away from plate boundaries. Called intraplate earthquakes, these events are not as well understood as the interplate earthquakes. Thus even though **southeastern Canada** is well away from the nearest plate boundary—the Mid-Atlantic Ridge—it seems that the slow movement of the North American Plate away from that rift boundary may generate compressive stresses that trigger earthquakes on old existing faults or zones of weakness such as those along the St. Lawrence and Ottawa valleys. Along the **eastern continental margin**, events are concentrated at the ocean-continent transition zone and in this case as well, appear to be caused by the reactivation of old faults. In **northern Canada**, earthquakes not only seem to be related to older geological features but may also result from differential uplift of the land since the last major glaciation. It is quite likely that not all of the active zones have been identified in these last two regions.

In Canada, earthquake information is gathered through a national network of seismograph stations that was initiated in the 1920s and completed in 1965. The network was considerably expanded in the 1970s, with the result that the Geological Survey of Canada currently operates more than 100 seismograph stations throughout the country. Information on large events that occurred before the development and installation of seismographs has been obtained from written accounts (diaries, newspapers, etc.) of earthquake shaking and damage. The historical record extends back to the 17th century in eastern Canada, but only to the latter part of the 19th century in western Canada. Most of the information on northern earthquakes dates from the completion of the national seismograph network.

This map was produced from a selection of earthquakes from the Canadian Earthquake Epicentre File, which contains data on more than 24 000 events known to have occurred in or near Canada. To obtain a fair representation of seismicity, the earthquakes were plotted according to magnitude. The symbols used for the larger or significant earthquakes inevitably mask smaller events; as well, because of the chronological order used for plotting, some of the earlier earthquakes may be hidden by more recent events.

The main map on this sheet is based on the *Seismicity Map of Canada* produced by F. M. Anglin, R. J. Wetmiller, R. B. Horner, G. C. Rogers and J. A. Drysdale. Specialist advice provided by R. North and data supplied F. M. Anglin, Geophysics Division, Geological Survey of Canada, Energy, Mines and Resources Canada. Additional research and adaptation for the National Atlas of Canada by M. A. Dubreuil and cartography by K. F. Siemonsen, National Atlas Information Service, Canada Centre for Mapping, Energy, Mines and Resources Canada.

DATE **MAGNITUDE** (Richter scale)

1568-1899	5.0 - 6.4
	≥ 6.5
1900-1964	4.0 - 4.9
	5.0 - 6.4
	≥ 6.5
1965-1991	3.0 - 4.9
	5.0 - 6.4
	≥ 6.5

Limit of data coverage

Circles with heavy rims represent significant earthquakes

SOME SIGNIFICANT EARTHQUAKES IN CANADA

Year	Date	Lat. °N	Long. °W	Mag.	Comments
1663	02/05	47.6	70.1	7.0	Charlevoix-Kamouraska region, Quebec. Widely felt. Reports of vast landslides in the St. Lawrence, Batiscan and St-Maurice valleys.
1732	09/16	45.5	73.6	5.8	Near Montréal, Quebec. Widely felt. About 300 houses damaged in the city of Montréal. No injuries.
1791	12/06	47.4	70.5	6.0	Charlevoix-Kamouraska region, Quebec. Widely felt. Some damage at Baie-St-Paul and Les Eboulements.
1860	10/17	47.5	70.1	6.0	Charlevoix-Kamouraska region, Quebec. Widely felt. Minor damage at Rivière-Ouelle.
1870	10/20	47.4	70.5	6.5	Charlevoix-Kamouraska region, Quebec. Widely felt. Minor damage at Baie-St-Paul.
1872	12/15	48.6	121.4	7.4	Washington-British Columbia border. Widely felt.
1899	09/04	60.0	142.0	7.9	Yukon-Alaska border. First of three great earthquakes in this region in the space of eight days. Strong effects experienced in many parts of northern British Columbia and southern Yukon.
1918	12/06	49.4	126.2	6.9	Vancouver Island. Widely felt. Some minor damage near Estevan Point.
1925	03/01	47.8	69.8	6.7	Charlevoix-Kamouraska region, Quebec. Widely felt. Considerable damage along the St. Lawrence River near the epicentre and some damage at Québec, Trois-Rivières and Shawinigan.
1929	05/26	51.5	130.7	7.0	Just south of the Queen Charlotte Islands.
1929	11/18	44.5	56.3	7.2	Atlantic Ocean, south of Newfoundland. Felt over a wide area of eastern North America. Twenty-seven people were drowned and much damage was caused by a 5-metre high tsunami on the Burin Peninsula. Most serious loss of life in any recorded Canadian earthquake.
1933	11/20	73.0	70.7	7.3	Baffin Bay. Largest earthquake ever known to occur north of the Arctic Circle.
1935	11/01	46.8	79.1	6.2	Quebec-Ontario border. Felt over much of eastern Canada. Minor damage at Témiscaming, Quebec, and North Bay and Mattawa, Ontario.
1944	09/06	45.0	74.9	5.6	Eastern Ontario-New York border. Widely felt. Damage at Cornwall (Ontario), Massena (New York) and nearby communities.
1946	06/23	49.8	125.3	7.3	Central Vancouver Island. Widely felt. Extensive damage along the east coast of Vancouver Island; one person was drowned.
1949	08/22	53.6	133.3	8.1	Off the Queen Charlotte Islands. Felt over a wide area of western North America. Canada's largest earthquake. Some damage on the Queen Charlotte Islands.
1958	07/10	58.3	136.5	7.9	Alaska-British Columbia border. Several people killed and much damage in Alaska. Parts of northwestern British Columbia and the southern Yukon were strongly shaken.
1970	06/24	51.8	130.8	7.4	South of the Queen Charlotte Islands. Widely felt.
1976	12/20	48.6	129.3	6.7	West of Vancouver Island.
1979	02/28	60.6	141.5	7.2	Yukon-Alaska border. Felt strongly in Canada. Minor property damage in the Yukon.
1980	12/17	49.4	129.6	6.8	West of Vancouver Island.
1985	12/23	62.2	124.2	6.9	Nahanni region, N.W.T. Widely felt in the Northwest Territories, Alberta and British Columbia. A smaller event (magnitude 6.6) that occurred in the same area two months earlier triggered an immense rock avalanche containing 5 to 7 million cubic metres of rock.
1988	11/25	48.1	71.2	6.0	Saguenay region, Quebec. Felt in a 1000-kilometre radius from the epicentre. Damage at Jonquière, Chicoutimi, La Baie, Québec, and as far away as Montréal.
1989	12/25	60.1	73.6	6.3	Ungava Peninsula, Quebec. First earthquake in eastern North America confirmed to have produced surface faulting.

Magnitude is a quantitative measure of the energy released during an earthquake. It is calculated from the amplitude of the seismic waves recorded by seismographs, and the distance separating the seismic station from the point of origin of the earthquake. Magnitude is most often expressed according to the Richter scale: this scale is logarithmic, so that each unit represents a tenfold change in the amplitude of ground vibrations. The amount of energy released increases by a factor of about 32 for each one-unit increase in magnitude. Magnitude 3 earthquakes are generally large enough to be felt, and events of magnitude 5 or greater are capable of producing damage.

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