Earthquakes in Saskatchewan and Canada

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Contents

EARTHQUAKES IN SASKATCHEWAN

THE BIGGEST EARTHQUAKE IN SASKATCHEWAN

The largest known earthquake in the northern plains region occurred May 15, 1909 at 10:15 PM. It was a Saturday night, and the stores were open in Regina. Shoppers were amazed to see goods on the shelves swaying back and forth. Many people noticed the vibrations. The earthquake was felt over all of southern Saskatchewan up to Saskatoon, as far east as Winnipeg, western North Dakota, and eastern Montana but there was little actual damage. A partly finished brick wall was knocked down. The engineer driving a train from Winnipeg to Regina noticed some unusual motion and stopped his train to investigate. On Monday the Regina Leader Post was filled with stories about the earthquake and speculations about its cause.

In 1909 there was only one seismograph in Canada, located in Ottawa, and it did record the earthquake but it was very far from the epicentre. Modern analysis of the 1909 eyewitness

reports has determined that the epicentre was near the US border where Montana, and North Dakota join. The magnitude was about 5 1/2 , a moderate earthquake, large enough to cause some damage. Fortunately in 1909 there was not much development in Southern Saskatchewan to be damaged.

SASKATCHEWAN EARTHQUAKE HISTORY

There were no seismographs in western Canada capable of detecting a small earthquake in Saskatchewan until the mid 1960's. People noticed small earthquakes before then but rarely reported them. Since 1968, 14 natural earthquakes are known to have occurred in Saskatchewan. The largest one was magnitude 3.9, August 17, 1982, near the town of Big Beaver close to the U.S. border. It was big enough to rattle the windows and crack plaster in a few houses. Other earthquakes were smaller, but still large enough to be noticed by people indoors.

Even now there are not enough seismographs in the region for very accurate mapping. Prairie region seismographs are located in Manitoba and Alberta, and only one is in Saskatchewan near Saskatoon, operated by the University. Seismic location of small events in Saskatchewan is uncertain by about 20 km. The smallest detectable event is about magnitude 2.5. Weaker events are just too small to be reliably measured by distant seismographs.

Since the region has proven capable of generating a magnitude 5 1/2 earthquake and a number of smaller ones in the last century, we may expect that another magnitude 5 1/2 or larger event will occur sooner or later. However, we have only about 30 years of instrumental recording in Saskatchewan, and the level of seismicity is low, so there is no possibility to predict when the next significant earthquake will occur. It could be this year, it could be in the next century or later. There is much more development now in Saskatchewan than there was 90 years ago, so some damage could be expected from a moderate earthquake as large as the 1909 one.

Seismologists record earthquakes in Universal Coordinated Time because earthquakes are detected in different time zones all over the world. Saskatchewan uses Central Standard Time which is 6 hours earlier than UCT. i.e. 04:15 May 16 UCT is the same as 22:15 May 15 CST in the following table:

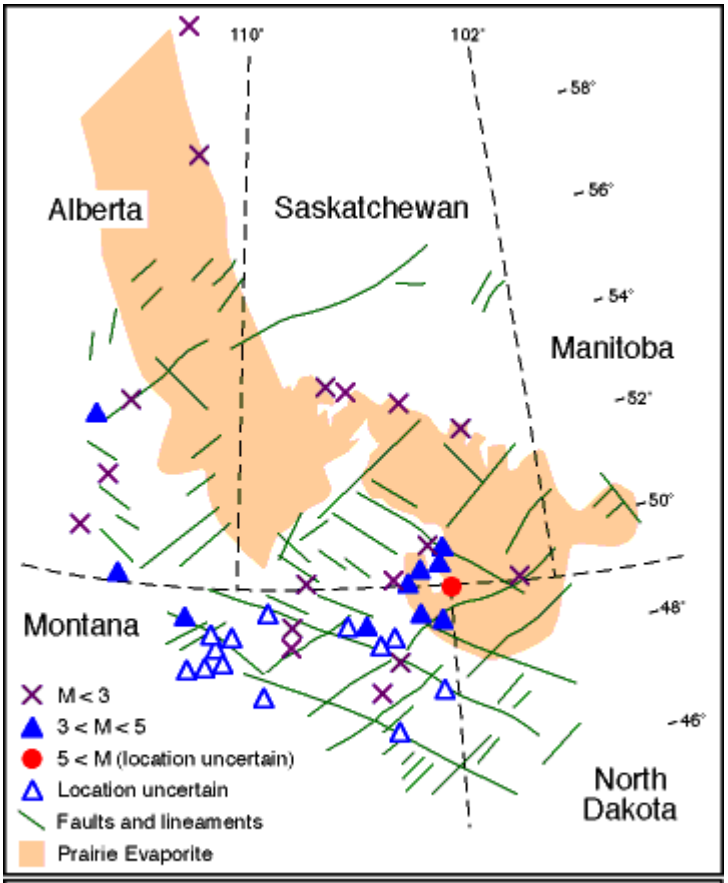
Table 1: Natural Earthquakes in Saskatchewan

Location	Date	UC Time	Latitude	Longitude	Magnitude
US Border	1909, May 16	04:15:00	49	104	5 1/2
*The 1909 earthquake was strongly was strongly felt in Saskatchewan. It was detected by a seismograph in Ottawa, Ontario. There were no instruments to detect small earthquakes in Saskatchewan before 1965.					
Val Marie	1968, Sep 11	12:00:06	49.25	108.14	2.70
Radville	1968, Oct 11	12:28:04	49.61	104.49	2.80
Bengough	1972, Jul 26	03:58:19	49.35	104.93	3.70
Radville	1976, Mar 23	22:31:47	49.56	104.37	3.20
	1976, Mar				

Radville	25	00:12:16	49.39	104.27	3.50
Humboldt	1976, May 15	06:21:12	52.45	105.44	2.30
Kuroki	1981, Jan 10	08:34:31	51.91	103.44	3.10
Big Beaver	1982, Aug 17	04:50:31	49.01	105.27	3.90
Redberry Lake	1984, Feb 05	04:30:14	52.7	106.95	2.30
Northgate	1985, Oct 10	12:43:37	49.07	102.17	2.90
Kuroki	1991, Apr 25	20:53:53	51.9	103.48	3.10
Kuroki	1991, Apr 26	00:02:26	51.9	103.48	2.50
Redberry Lake	1993, Nov 08	16:20:44	52.7	107.3	2.60
Coronach	1997, Apr 18	00:25:39	49.08	105.38	3.00

CAUSES OF SASKATCHEWAN EARTHQUAKES

The northern plains seismic zone includes a region of south central Saskatchewan and northeast Montana. The 1909 event and a scattering of small earthquakes may be related to two possible causes: small faults known to exist in the subsurface, and the Prairie Evaporite formation which is composed of rock salt.



Known natural earthquakes of the Northern Plains Seismic Zone as of 1998

I) FAULTS

A system of faults cuts the rocks of southern Saskatchewan. They are not large like the famous San Andreas fault of California, but they are a result of long term stress in the earth's crust, and some have rocks displaced on either side. Little is known about them because all of southern Saskatchewan is covered with sediment deposited by Pleistocene glaciers, and the faults are not easily seen. Nevertheless, some earthquakes are located close to faults, suggesting that the faults may be responsible for them. Faults may be related to uplift of the plains region, which was once under the sea, or to continental stress fields related to the building of the Rocky Mountains.

II) SALT REMOVAL

The Prairie Evaporite formation is a layer of solid rock-salt, up to 200 m thick, which underlies most of southern Saskatchewan and extends into Manitoba, North Dakota, Montana, and Alberta. The salt is mostly the same chemical as ordinary table salt, soluble in water, but crystallized into a solid form. It was deposited in an ancient sea about 370 million years ago, then covered by layers of limestone and shale, hundreds of metres thick. The area underlain by salt was once much larger, but ever since the salt was deposited, groundwater has slowly dissolved and carried it away. Ground water continues to dissolve the salt today, especially around the edges, but also at some locations in the interior of the enormous sheet.

Many small Saskatchewan earthquakes are located near the edges of the Prairie Evaporite salt, where active dissolution is taking place. As the salt is dissolved, support is removed for rocks that lie on top of the salt, so the overlying rocks slump down as they are under-mined. If the rock is weak or already fractured, it settles quietly. However, if the overlying rock is a strong limestone it may resist movement, forming a bridge over the under-mined area. When the under-mined area gets large, the rock-bridge fractures and fails in a violent manner, causing an earthquake. Some earthquakes in southern Saskatchewan are of this type, and also a few small ones located north and east of Saskatoon. No large sinkholes have been observed at earthquake sites so it is unlikely that any large cavity ever forms in the salt. The dissolution may take place in a spongy, honeycomb pattern which gradually weakens the formerly solid rock-salt.

Dissolution of the salt may be localized by active or in-active faults which provide a seepage path where ground water can flow and contact the salt. In such a case, the distinction between salt removal and faulting as a cause for an earthquake is blurred.

CANADIAN EARTHQUAKES

Although many people do not realize it, Canada is earthquake country. There are many areas at risk from earthquakes, the British Columbia coast, the St. Lawrence river valley, the Mackenzie mountains, and several places in the Arctic Islands. Manitoba, Saskatchewan and adjoining Northwest territories are areas least at risk from earthquakes.

WESTERN CANADIAN EARTHQUAKES

CANADA'S LARGEST EARTHQUAKE

The largest earthquake in Canadian history occurred near the Queen Charlotte Islands off the coast of British Columbia on the evening of August 21, 1949. This was a giant earthquake with magnitude 8.1. The fault rupture began in the ocean bottom just offshore the rugged coast of Graham Island, the large northern island of the Queen Charlotte group, and spread more than 500 Km along the Queen Charlotte fault. The Queen Charlotte fault is a major fault in the ocean floor extending from northern Vancouver Island, west of the Queen Charlotte Islands, up to the Gulf of Alaska. The Queen Charlotte islands are sparsely populated. No one died in this earthquake but there were landslides and other damage, people and even cows were knocked off their feet. In Prince Rupert, 200 Km away on the mainland, windows were shattered and buildings swayed. It was felt throughout British Columbia, and parts of Washington state, Alberta, the Yukon, and Alaska.

CANADA'S EARTHQUAKE HISTORY

The offshore region and western part of British Columbia is one of the highly active seismic regions of the world. In addition to the 1949 giant earthquake there have been large earthquakes in 1872, 1899, 1918, 1929, 1946, 1958, 1970, 1976, 1979, 1980 with magnitudes between 6.7 and 7.9, all potentially very destructive. Fortunately, most of them occurred offshore or in remote regions so there were few deaths and moderate damage. However, not all were in remote regions, the magnitude 7.4 earthquake of 1872 was centered on the mainland east of Vancouver, the magnitude 7.3 earthquake of 1947 and magnitude 6.9 of 1918 occurred in the middle of Vancouver Island and both of them caused damage. There are of course many smaller earthquakes that occur every year, and a few are large enough to cause local damage.

ORIGIN OF WESTERN EARTHQUAKES

Offshore earthquakes in British Columbia are mostly associated with the Queen Charlotte fault or one of its subsidiaries. The Queen Charlotte is a strike slip fault, similar to the San Andreas fault of California, and capable of generating equally large earthquakes. However the Queen Charlotte fault is offshore, whereas the San Andreas fault bisects major cities.

The Juan de Fuca plate is a completely different geological structure that separates the Queen Charlotte fault from the San Andreas fault. The Juan de Fuca plate extends from central Vancouver Island to southern Oregon. The Juan de Fuca plate is a large part of the Pacific ocean floor which is slowly moving, driven by tectonic forces deep within the earth, and pushing under the coast of Oregon, Washington, and British Columbia. The process is called subduction. The Juan de Fuca plate thrust under the North American coast causes the coastal mountains to rise and causes the volcanoes such as Mount Baker, Mount St. Helens Mount Shasta, etc.

Movement of the Juan de Fuca plate is thought to have caused a super giant earthquake on January 26 in the year 1700. Canadian, Japanese, and American scientists have found evidence in Indian legends, sea bottom sediment, and Japanese tsunami records, that an earthquake occurred off western Vancouver Island with magnitude 9 or greater. Large sections of coast were drowned, Indian villages were lost, and a great sea wave or tsunami was observed hours later in Japan. Geological evidence shows that large earthquakes have in fact occurred repeatedly on the west coast in the past. Current observations of seismic activity and uplift of the coastal regions suggests that another super giant earthquake may be in the making.

EASTERN CANADIAN EARTHQUAKES

EASTERN EARTHQUAKE HISTORY

Large earthquakes have also occurred in eastern Canada. The earliest known was recorded by settlers in 1663. Modern analysis of the early reports suggests magnitude 7.0. It was located in the Charlevois-Kamouraska region of Quebec and caused extensive landslides in the area. The rivers ran muddy for many days after. The Charlevois-Kamouraska region also had large earthquakes in 1791, 1860, 1925 and many smaller ones up to the present. An earthquake estimated to be magnitude 5.8 struck Montreal in 1732, damaging 300 houses. In 1929, a magnitude 7.2 earthquake hit the ocean floor south of Newfoundland, creating a 5 m high tsunami that struck the coast of Newfoundland, drowning 27 people, the largest earthquake death toll in Canada. The same earthquake also cut numerous transatlantic telephone cables on the ocean floor. In 1988, a magnitude 6.0 earthquake struck the Saguenay region, in a wilderness area south of Chicoutimi Quebec, at the time of the evening TV news. It was felt and immediately commented by a TV newscaster more than 1000 Km away. There are many others, large and small, in eastern Canada and eastern United States.

CAUSES OF EASTERN EARTHQUAKES

A surprising characteristic of eastern North American earthquakes is that the fault structures responsible are almost never exposed on the surface. Consequently, it is difficult to find good geological explanations, and there is no unifying theory for the origin of eastern earthquakes as there is for many western earthquakes. In the case of the New Madrid earthquakes, the rock that ruptured is buried under thousands of metres of sediment. Landslides and other surface features are a result of the earthquake, not its cause. Similarly for the Saguenay earthquake, scientists searched the area for months, but found nothing except secondary fractures in the surface rocks.

In some areas a geological cause can be identified. For example, in the Charlevois-Kamouraska region, there is a large, ancient meteorite impact crater that lies across a major geological boundary. Many earthquakes are located in and near the crater. The St. Lawrence river covers most of the ancient crater but careful geological mapping has revealed that the crater is a zone of weakness responsible for earthquakes.

Some earthquakes are related to old fault systems that bound Precambrian rock units of the Canadian shield. The principle ones include the Logan's line, a major geological contact that parallels the St. Lawrence river. Another is the Ottawa graben, a large rock unit bounded approximately by the Ottawa, St Lawrence, and Saguenay rivers. No measureable displacement has ever been observed on any of these old faults as a result of a modern earthquake. The rock that ruptures is far below the surface. Moreover, earthquakes are not neatly confined to the boundaries of these zones, and many occur in other areas. Sometimes significant earthquakes occur far from where any was ever noticed before, such as the 1985 Mirimichi earthquake in central New Brunswick, and the 1989 Ungava earthquake in Northern Quebec.

With only a few decades of instrumental recording in Canada, there is still much to learn about Canadian earthquakes.

NORTH AMERICA'S LARGEST EARTHQUAKE

The largest earthquake known in North America was not in California but in the New Madrid area of Missouri, near the confluence of the Ohio and Mississippi rivers. In the space of a few days on December 16, 1811, January 23, 1812, and February 7, 1812, there were three great earthquakes, all estimated greater than magnitude 8, and many large aftershocks. Some people were killed in the area's frontier settlements. The earthquakes caused great landslides along the rivers, drowning some people. A temporary waterfall appeared in the Mississippi river. A large permanent lake, Reelfoot lake, suddenly appeared in western Tennessee. The earthquakes rang church bells in Boston, and were felt all over the eastern United States and in parts of Canada and Mexico. Small aftershocks of these giant earthquakes are still instrumentally recorded in the area almost two centuries later.