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EARTHQUAKES IN CANADA

The diaries of Jacques Cartier contain the first reference to a large earthquake in the historical records of Canada. This was an event that probably occurred around 1534 near La Malbaie, about 100 km downriver from Quebec City. However, the legends of the West Coast Indians seem to recall earthquakes from much earlier than this, confirming evidence that Canada has areas in which earthquakes regularly occur.

Magnitudes of the early earthquakes have to be estimated from the historical reports of damage and ground shaking. Because the nature of the local rocks and the geological structure of a region affect the intensity of ground movement, these estimates are being continually refined in the light of better knowledge and the observation of later events. Two of the largest of these early earthquakes were an estimated magnitude 7.5, which occurred near the mouth of the Saguenay River in 1663, and an estimated magnitude 7.5 east of Vancouver in 1872.

In this century there have been eight events of magnitude 7 or 8 in Canada. In eastern Canada, a magnitude 7 earthquake occurred in 1925, again near La Malbaie in the St. Lawrence Valley. This was felt as far west as the Mississippi and as far south as Virginia. Although no one was killed or injured, most chimneys in the immediate epicentral area were destroyed and many stone buildings were damaged beyond repair. The great stone chimney of the church at Rivière-Ouelle fell through the roof and the organ pipes were thrown into the auditorium. Considerable damage was caused at Quebec City, Trois-Rivières and Shawinigan Falls.

Only four years later, in 1929, a submarine earthquake (magnitude 7.2) beneath the Grand Banks south of Newfoundland caused an underwater landslide. This broke 12 trans-Atlantic cables in 28 places and set up a seismic sea-wave (tsunami), which drowned 27 people. The wave was 5 metres high and struck the south coast of the Burin Peninsula, sweeping away houses and causing an estimated \$1 million damage. This was the most serious loss of life in any recorded Canadian earthquake.

On the west coast, magnitude 7 earthquakes occurred on Vancouver Island in 1918 and offshore in 1929. One of the best documented quakes was the 1946 magnitude 7.3 event near the east coast of Vancouver Island. At 10 am on Sunday, June 23, a shock was felt over most of Vancouver Island and throughout the Vancouver and Lower Mainland areas. Landslides and slumping occurred, and the shaking caused masonry to break and chimneys to fall. Inside buildings, shop goods and household objects were shaken off their shelves. Most of the serious damage was restricted to the east coast of the island. In the Courtenay area, 30 schools had to be closed because of earthquake damage. At one school a heavy chimney crashed through the roof into an empty classroom. The only person killed was a man who drowned when his boat was tipped by a wave created by subsidence along the shore of a lake.

The largest recorded earthquake in Canada, with a magnitude of 8.1, occurred off the Queen Charlotte Islands in 1949. However, because the islands are sparsely populated, the amount of damage was slight.

In 1970 a magnitude 7.4 earthquake occurred just south of the islands but was too far offshore to cause any damage. Similarly, there was no recorded damage from a magnitude 7.2 earthquake in 1979 in a remote area on the Alaska-Yukon border.

One of the most spectacular results from a recent earthquake in Canada occurred on October 5, 1985. A magnitude 6.6 earthquake located near the North Nahanni River in the Northwest Territories triggered an immense rock avalanche containing an estimated 5 million to 7 million cubic metres of rock. Half a square kilometre of mountainside became detached and trees and automobile-sized blocks of rock slid 1.5 kilometres down a narrow valley. Fortunately the area is uninhabited.

Although Canada has been lucky to escape a major disaster so far, it has a long and continuing earthquake history and much of its population now lives in earthquake zones. A map of the earthquakes that have been recorded in Canada shows that they occur in four principal areas:

- on the west coast, around Victoria and Vancouver, offshore northern Vancouver Island and through the Queen Charlotte Islands and the Alaskan Panhandle to the southern Yukon;
- in the Mackenzie Valley of the Northwest Territories, particularly in the Richardson and Mackenzie Mountains;
- in the Arctic Islands and along the northeast coast of Baffin Island and Baffin Bay; and
- in the Ottawa and St. Lawrence valleys, in New Brunswick and south of Newfoundland.

One of the goals of the Geological Survey of Canada is to develop a better understanding of the cause of these earthquakes. In the broadest terms, the earthquakes are due to continual forces that are slowly reshaping the earth's surface as part of its geological evolution.

Along the west coast, they are caused by the slow movement of a series of major plates forming the earth's lithosphere (the outer cool, rigid part of the globe). In the area of the Queen Charlotte Islands, two of the largest plates on the earth - the North American Plate and the Pacific Plate - are sliding past each other at about 6 mm per year. Farther

south, in California, the same action results in the San Andreas Fault. Between California and the Queen Charlotte Islands, a smaller plate - the Juan de Fuca Plate - is thrusting beneath the continent at about 4 cm per year, eventually melting to produce the Cascade Range of volcanoes, including Mount St. Helens.

By contrast, eastern Canada lies entirely within the North American Plate and far from its active boundaries in the centre of the Atlantic Ocean and along the west coast. The forces producing earthquakes here are different. It seems that the slow movement of the North American Plate away from the Mid-Atlantic Ridge may activate old zones of weakness and faults such as the St. Lawrence Valley, causing them to readjust and accommodate the continuing strain. The earthquakes of the Northwest Territories may be similar 'adjustments' within the folded and thrust rocks of the western mountain belts.

In the Arctic Islands and Baffin Island, earthquakes also seem to be associated with older geological features. They may, however, also be related to stresses produced during the uplift of the land after the removal of the ice sheets of the last major glaciation of the Arctic region.

By understanding the origin of the forces that produce Canada's earthquakes, the Geological Survey can develop better estimates of their probable future size, location and frequency. This understanding forms the basis for developing estimates of earthquake hazard and for designing buildings and structures that are safe and secure.

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