

The Vancouver Area – On Shaky Ground

by Denny Capps

Introduction

The Vancouver area has a long history of damaging earthquakes and it will experience many more in the future. Unfortunately, seismologists (scientists who study earthquakes) still cannot predict earthquakes accurately. However, we do know that the Vancouver area is at risk from earthquakes, how likely earthquakes are to occur, and what the damaging effects of these earthquakes will be.

The purpose of this article is to provide an overview of our earthquake hazard so that you can be better prepared when an earthquake occurs. The recent earthquake, tsunami, and hurricane disasters underscore the importance of an informed populace in minimizing loss of life and property.

Some significant earthquakes felt in Vancouver

Date	Location	Magnitude	Comment
January 26, 1700	West of Vancouver Island	8+	Great earthquake; native villages destroyed
December 15, 1872	North-central Washington	7.4	Felt strongly in the Lower Mainland
January 11, 1909	San Juan Islands	6	Deep, felt strongly in the Lower Mainland
December 6, 1918	Vancouver Island	7	Damage on west coast of Vancouver Island
January, 24, 1920	San Juan Islands	5.5	Deep, felt strongly in the Lower Mainland
June 23, 1946	Vancouver Island	7.3	Much damage on central Vancouver Island
April 13, 1949	Puget Lowland	7	Deep, much damage in Seattle and Tacoma
April 29, 1965	Puget Lowland	6.5	Deep, much damage in Seattle
November 30, 1975	Strait of Georgia	4.9	Shallow, many aftershocks
May 16, 1976	Southern Gulf Islands	5.4	Deep
April 14, 1990	Fraser Lowland	4.9	Shallow, many aftershocks
February 28, 2001	Puget Lowland	6.8	Deep, much damage in Seattle and Olympia

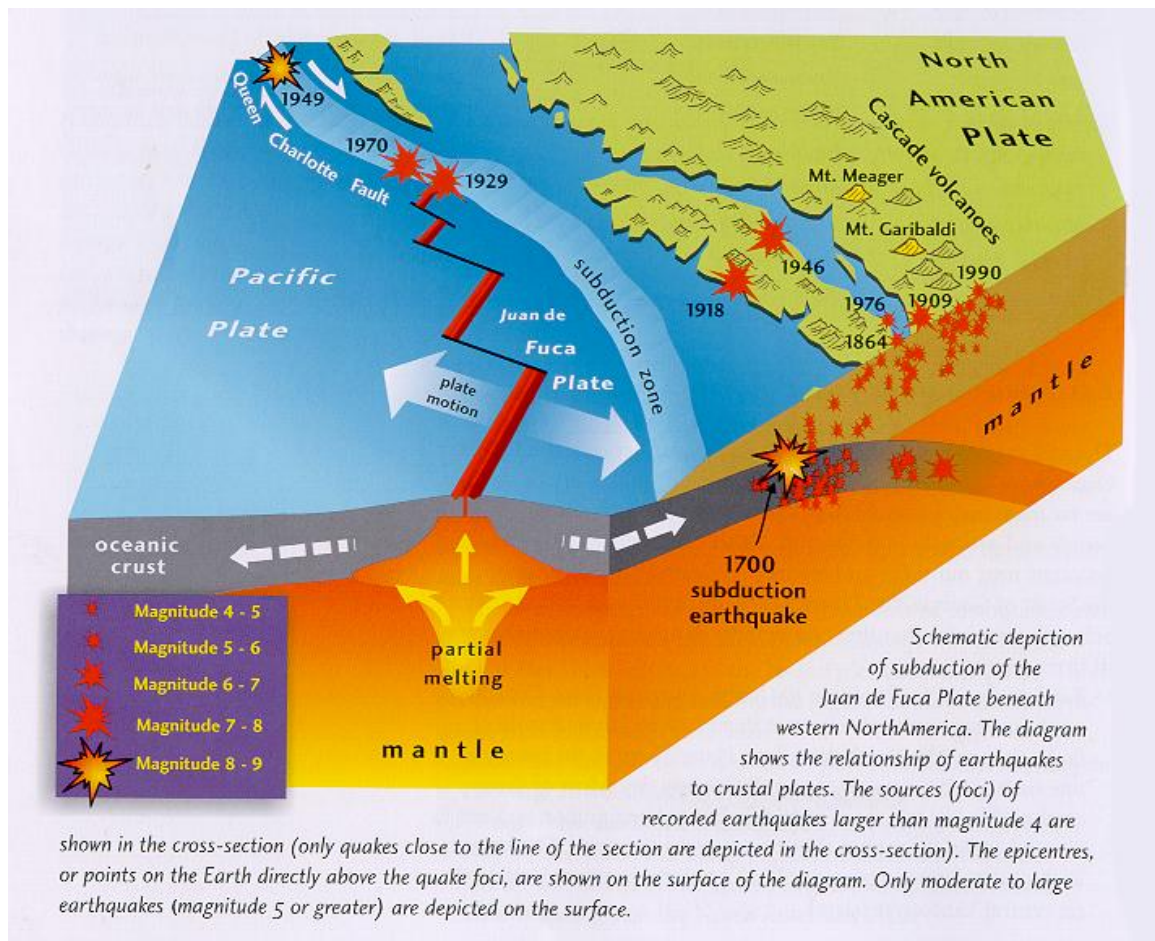
What is an earthquake?

An earthquake is the result of a sudden release of energy when rocks break and move rapidly past one another along a fault. The sudden slip along the fault, which may or may not extend to the surface, causes the ground to shake.

Earthquakes and Plate Tectonics

Stress that causes earthquakes results from the movement of rigid plates that make up the outer shell of the Earth. These plates “float” on the outer mantle, a dense, hot, deformable layer. The plates move due to convection (the transfer of heat by moving fluids) in the mantle. The movement is slow, typically several centimetres per year, or about the rate at which fingernails grow. Consequently, we do not notice the movements in our everyday lives. Over time however, these small movements can build up enough stress to produce large earthquakes.

The west coast of BC is located within a belt of earthquakes and volcanoes that marks the boundaries of several plates. Three plates meet off our coast, making the region the most active earthquake zone in Canada. About 200 km off the west coast of Vancouver Island, the Juan de Fuca and Pacific Plates are spreading apart. Closer to the coast, the Juan de Fuca Plate moves beneath the North American Plate along the Cascadia subduction zone (an area where one plate pushes below the edge of another). Off the west coast of the Queen Charlotte Islands, the Pacific Plate is sliding past the North American Plate.



Types of Earthquakes that Could Affect Us

Seismologists infer that these potentially damaging earthquakes are of three types. Crustal earthquakes occur on faults within the North American Plate at depths of 20 km or less, which is relatively shallow. There is, on average, one such earthquake in southwestern BC every day. Most of these earthquakes are too small to be felt, but a damaging one occurs somewhere in the region about once every ten years. The largest in this century was a magnitude 7.3 earthquake in 1946 on central Vancouver Island. Some people reported feeling it as far away as Portland, Oregon.

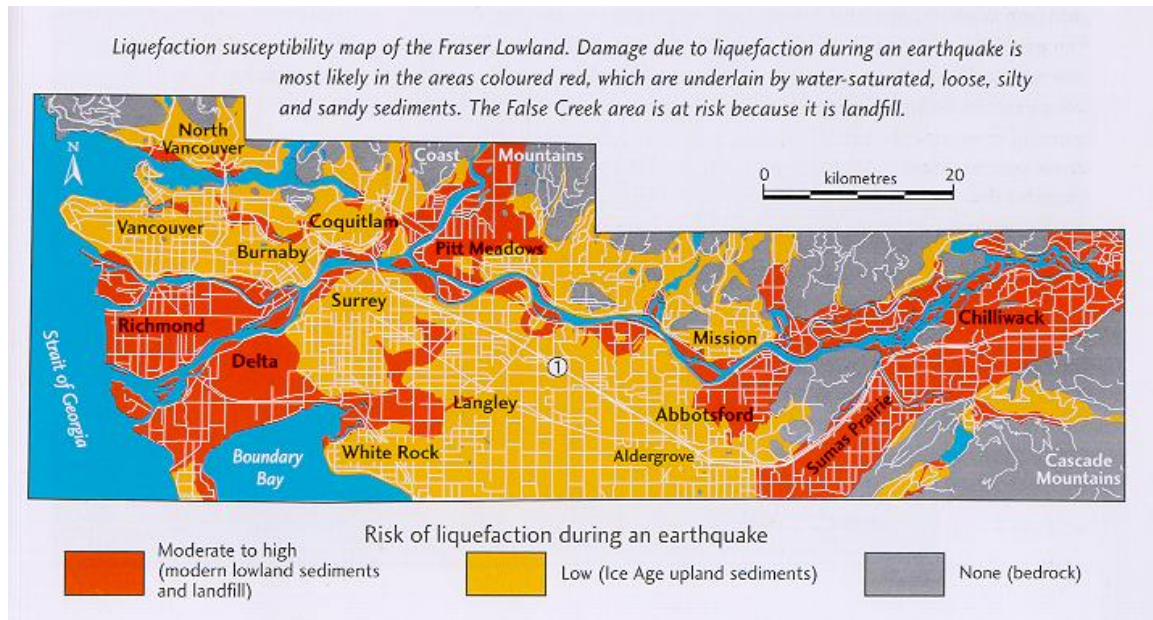
Subcrustal earthquakes occur within the subducting Juan de Fuca Plate as deep as 80 km. There have been several destructive earthquakes of this type beneath Puget Sound in the historical period. The most recent example occurred near Olympia, Washington in February 2001, which caused billions of dollars of damage. Many people in the Vancouver area felt this earthquake.

Subduction earthquakes occur at the boundary between the North American and Juan de Fuca Plates at widely varying depths. Generally, they occur at depths of 20 km or less, but they have occurred as deep as 700 km. Also known as “mega quakes”, they occur along the large fault that separates the converging Juan de Fuca and North American Plates. Rupture takes place over a vast area of the fault plane and consequently produces extremely large (magnitude 8 or 9) earthquakes. The catastrophic Sumatran earthquake of December 26, 2004 and its resulting tsunami were a result of this type of fault. There is abundant geological evidence for a great earthquake off our coast in AD 1700 and for many others in the past few thousand years. Geophysical measurements show stress building up towards the next cataclysm. The data reveal that Vancouver Island is bulging slightly upwards and is contracting above the downgoing Juan de Fuca Plate, as would be expected if the two plates are stuck and not moving smoothly past each other. In a subduction earthquake, the fault releases accumulated stress suddenly and the plate “snaps” back, potentially triggering a tsunami.

Types of Earthquake Damage

Direct earthquake effects include strong ground shaking, and ground failure and cracking. Earthquakes are most destructive when centred near cities, but the damage can differ considerably from place to place because of local ground conditions and building construction. For example, shaking on loose, modern sediment is generally greater than shaking on bedrock (solid rock). The primary factors to consider in building construction include materials used (wood or masonry, for example), number of floors, and design.

Earthquake shaking can also cause liquefaction, which transforms some loose, water-saturated silt and sand into fluid material. Quicksand, although not a technical term, is a type of liquefied sediment. Liquefied silt and sand may move upward along cracks in the ground and erupt onto the surface to form sand volcanoes. At depth, the liquefied sediments lose their strength and cease to support buildings and other structures built on them. The buildings may sink or lean, or their foundations may crack due to irregular settling or horizontal movement. Materials most likely to liquefy include landfill and poorly compacted sand and silt located along the coast and beneath deltas and river plains. An area of particular concern is the Fraser River delta. A thick layer of liquefiable wet sand lies beneath a capping layer of silt and peat (partially decomposed organic matter) throughout much of the delta plain. Geoscientists have found widespread evidence on the delta of liquefaction triggered by a large prehistoric earthquake, and engineering tests indicate that the buried sand unit will liquefy if strongly shaken during a future earthquake.

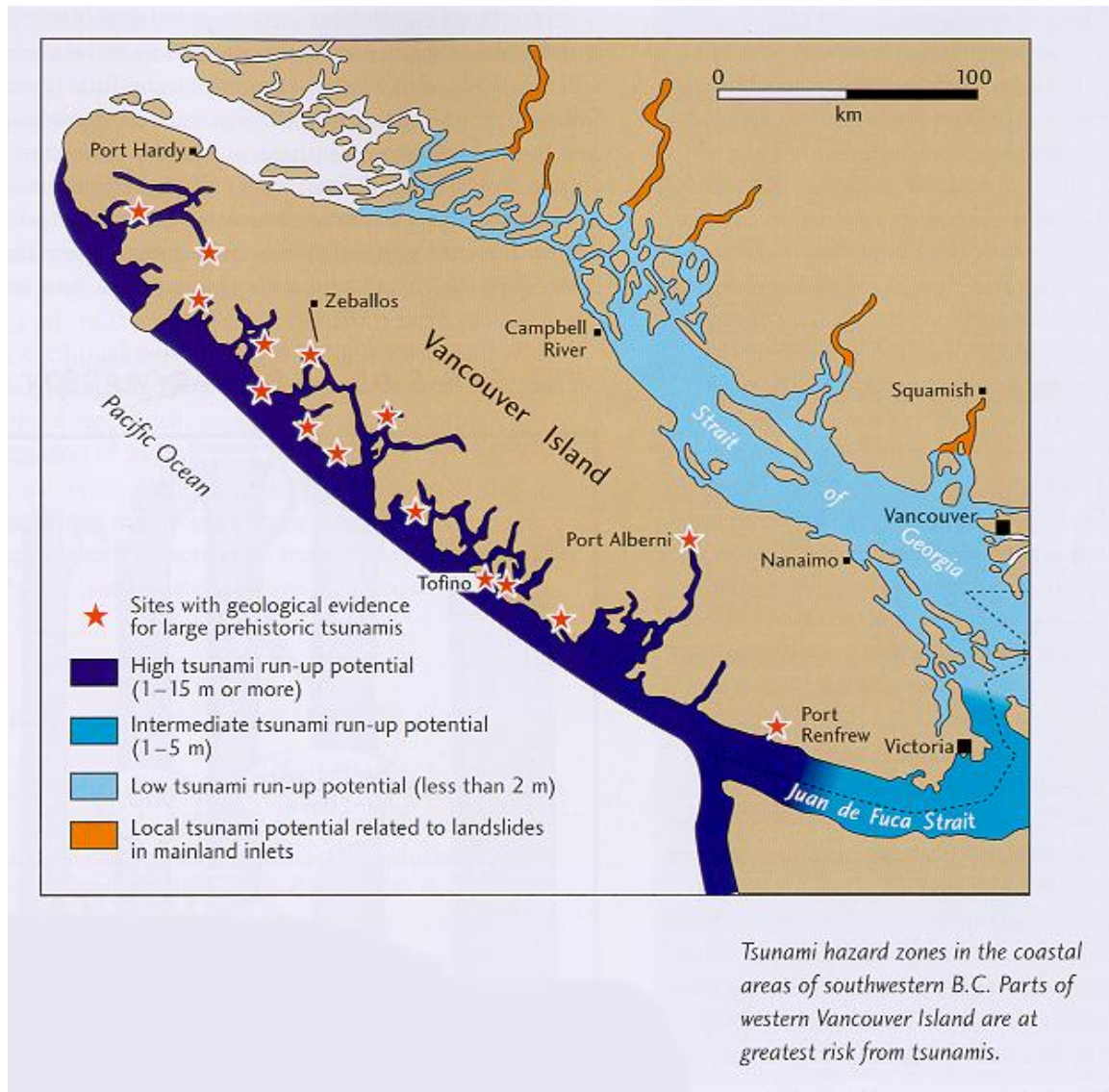


Ground rupture occurs when rapid movement along one or more faults extends to the surface. Ground rupture can be disastrous to bridges, utility lines, dams, and other structures that cross the fault. Fault rupture zones range in size from less than one metre to hundreds of metres wide.

Earthquake-induced landslides occur most commonly on steep slopes underlain by loose sediments or unstable rock. Landslides are a particularly significant seismic hazard in southwestern BC because steep slopes are common in the region. Highways, rail lines, and utility lines that pass through valleys and canyons bordered by steep, potentially unstable slopes can be blocked or severed by landslides. A large earthquake might cause numerous blockages over a large area, disrupting economic activity and restricting access to the affected region. In this context, even small landslides, which are the vast majority of those triggered by earthquakes, can be severely disruptive.

Earthquake-Induced Tsunamis

Some earthquakes trigger destructive sea waves, termed tsunamis. Large tsunamis can surge 1 to 2 km inland and reach heights of 30 m or more above sea level, causing loss of life and severe property damage like that from the Sumatran tsunami. Earthquakes in the north Pacific are the main sources of tsunamis on our coast. The threat is greatest on western Vancouver Island. The Strait of Georgia is protected from the open ocean, thus the tsunami hazard is low at Vancouver. Much energy is lost as the tsunami passes through narrow passages connecting the Juan de Fuca Strait, and tsunami amplitudes are reduced to a metre or less by the time the waves reach Vancouver.



Summary

A large earthquake can cost billions of dollars and claim thousands of lives. Although we cannot prevent earthquakes, the damage that they cause can be reduced through geological and geophysical studies, proper design of buildings, planning, and public education. For example, areas of possible severe ground shaking, liquefaction, or landslides can be identified through geological mapping. Mapping can aid in urban planning and in developing emergency procedures for earthquakes. Continuous monitoring of seismic activity by the Geological Survey of Canada improves our understanding of earthquake hazards in our region. The Centre for Natural Hazard Research (<http://www.sfu.ca/cnhr/>) was recently established at SFU; its mandate is to conduct innovative research on geophysical processes that are a threat to the population and economic infrastructure of Canada.

Now, if anyone asks if you are aware of the earthquake hazard in the Vancouver area, you can answer a strong “YES!” The question that I ask you is, “ARE YOU

PREPARED?” For information on personal earthquake preparedness, see the British Columbia Provincial Emergency Program for Earthquakes at http://www.pep.bc.ca/hazard_preparedness/Earthquake_Information.html.

This article is largely an excerpt from *Vancouver, City on the Edge*, with permission from authors Dr. John Clague of the SFU Department of Earth Sciences and Dr. Bob Turner of the Canadian Geological Survey.

CAUGHT IN AN EARTHQUAKE ON CAMPUS?

WHAT WILL HAPPEN?

Apart from the obvious things like the ground shaking, the lights and hanging structures swinging, furniture falling, and any unsecured PCs, books, etc. flying around the power may go out and the fire alarms may sound.

WHAT YOU SHOULD DO

DROP, COVER AND HOLD if you are in a building!

This means if you are in a building **STAY** there!

Drop down and take **cover** under a heavy desk or table and **hold** on as that piece of cover will probably move and you need to keep under it. If there is nothing to protect you, crouch against an interior wall or corner protecting your head and neck with your arms staying away from windows or anything that could fall on you.

In a library move away from the shelving area. Inner walls should be safest. In a laboratory move out to a corridor. In a classroom crouch on the floor under the tables or if you are in a lecture theatre crouch between the seats and cover your head and neck.

If you are outside, **STAY** there and move to an open space away from buildings, trees and power lines.

If you're in a car, **STAY** there. If possible avoid stopping near tall buildings, underpasses, trees and power lines. The car will protect you from flying debris.

DO NOT exit or enter a building. There is danger of falling debris and flying glass.

AFTER THE QUAKE

Count to 60 after all motion has stopped before moving from your cover.
Be alert for aftershocks!
Extinguish open flames and terminate hazardous work procedures.
Administer First Aid to injured persons as needed.
Do not use elevators; turn on lights or use flashlights.
Evacuate the building carefully. Be aware of possible additional hazards of fire, flooding and gas leaks.
Go to a pre-established emergency meeting place.
Keep roads clear for emergency vehicles.

DO NOT make telephone calls unless they are lifesaving.
AN OVERLOADED TELEPHONE SYSTEM BECOMES WORTHLESS IN A DISASTER.

Listen to a portable radio for further information.
STAY CALM, use common sense and cooperate with emergency officials.

Burnaby Campus

Call 604-291-4500 for all emergencies (24 hours)

SFU Vancouver

Call 604-291-5252 for all emergencies (24 hours)

SFU Surrey

Call 604-268-7511 for all emergencies (24 hours)

Or send a messenger to Security to report medical emergencies, fires, gas leaks, chemical spills, building damage, electrical or any other hazards.

GET PREPARED BEFORE IT HAPPENS!

Additional information is available on the Emergency Preparedness web site at www.sfu.ca/hr/emergency-preparedness.html, from the SFU Emergency Preparedness Office, AQ 3012, call 604-268-6740 or e-mail: emerprep@sfu.ca.