Hazard Risk Analysis

Earthquakes, Tsunamis and Volcanoes

Earthquakes

Definition

Earthquakes are considered to be a special type of geological hazard. An earthquake is a series of waves that travel through the earth. Earthquakes often start where 'stress or pressure' along a fault becomes too strong for the rock, so that sudden movement occurs along the fault. The ground motion creates other hazards, namely surface faulting, changes in land elevation, ground failure, liquefaction and tsunamis.

The focus of an earthquake is the point where movement on the fault starts, and the point from where seismic waves radiate and travel through the earth. The epicentre is the point on the earth's surface directly above the focus. A fault is the surface along which a rock body has broken and been displaced.

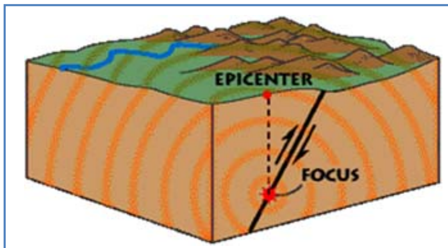

Figure 1. Earthquake focus and epicentre. Thick black line is the fault surface, arrows show movement along the fault.

There are various ways earthquakes can cause damage, injury and death:

- **Shaking** and **ground rupture** are often the first signs of an earthquake. Violent shaking can severly damage buildings and infrastructure (especially bridges). Ground shaking can knock people off their feet. During an earthquake, the earth's crust not only vibrates, but segments of it are fractured and displaced, and cracks in the earth's surface open up. "Surface faulting" is the tearing of the Earth's surface by movement across a fault. Earthquakes are sometimes only felt very locally, but at other times earthquakes happen over larger regions.

- **Changes in land elevation** are a very common effect of earthquakes. Some parts of the Earth will be uplifted, whereas other parts may have sunk. These changes in land elevation have been known to change the course of river streams, or uplift parts of the coast line. The effects can be dramatic, as the uplift of the coast can cause marine life to die, and the sinking of land near rivers can cause serious flooding.

- **Liquefaction** (or **ground failure**) is another major effect of earthquakes. Liqefaction typically occurs in soils that have a high water content. The shaking from the earthquake increases the water pressure at shallow depths. Soil and sediment particles on top of this water will then start floating and flowing. Once the pressure in the underground water settles again, the soils and sediment will turn from a "liquid" to a solid again. Liquefaction can cause serious damage to buildings. Liquefaction is often described as "suddenly emerging quicksand." though that is a bit exaggerated. There are several signs of liquefaction to look for:

Figure 2. Lateral spreads caused by liquefaction of the soil (Photo: USGS Multimedia Gallery).

- **Lateral spreads** involve the sideways movement of large blocks of soil on the surface as a result of liquefaction in layers below (Fig.2). Lateral spreads generally develop on very gentle slopes (most commonly between 0.3 and 3 degrees) and move toward a free face, such as a stream channel. Lateral spreads often disrupt the foundations of buildings or other structures, rupture pipelines and other utilities in the failure mass.

- **Flow failures** are liquefaction-caused landslides that develop in loose sands or silts with a high water content, on natural or man-made slopes greater than 3 degrees. They often displace large masses of material for many metres at velocities ranging up to tens of miles per hour.

Figure 3. Sand boil (Photo: www.showme.net).

Figure 4. Buildings have toppled due to a loss of the bearing capacity of the ground (Photo: www.nap.edu).

- **Sand boils** or **sand blows** often form at the surface, and are small mounts of sand from which water squirts out of the ground (Fig.3).

- **Loss of bearing capacity** occurs when the soil supporting a building or other structure liquefies and loses strength. This process results in large soil deformations under load, allowing the structures to settle and tip (Fig.4). The loss of bearing capacity of a soil has been known to topple 4-story high buildings, collapse highway bridges and fail dams..

- Other hazards that are related to earthquakes are **fires**, **landslides** and the **outbreak of diseases.** The shaking during an earthquake can cause natural gas and oil (pipe)lines and electrical power lines to break, which can easily start fires. Landslides due to earthquakes can happen in any mountainous area, but especially in areas where the ground holds a lot of water (see “flow failures” above). The outbreak of diseases has happened as a result of very large earthquakes, when water and sewage lines are broken.

Some earthquakes are caused by human activity.The injection of fluids into deep wells for waste disposal, the recovery of oil and gas, and the use of reservoirs for water supplies have all been linked with the occurrence of earthquakes. Fortunately, most of these earthquakes are minor.

Discussion

Magnitude and Intensity

There are 2 ways to measure the effects of an earthquake: **Magnitude** or **Intensity**.

Magnitude is a measure of the amount of energy released by an earthquake. It is most commonly expressed as a relative magnitude on the Richter Scale (which measures the seismic wave amplitude on a logarithmic scale, to the base 10, as defined in 1935 by Charles R. Richter).

It is unusual for shocks smaller than magnitude 2 to be felt anywhere. Earthquakes with magnitude of 3 can be felt by humans when near the epicentre of the quake. Damage begins to occur to buildings at about a magnitude of 6. Any earthquake above magnitude 7 can be a major disaster if it occurs near a densely populated area. We don’t know much about earthquakes that happened in the past, as measuring equipment was not available to determine the magnitude of past earthquakes. Generally, most seismologists feel that historical earthquakes have not exceeded a magnitude of 9 to 9.2.

Seismic activity is also expressed in terms of felt intensities on the Modified Mercalli Scale. Each level of intensity is based on a description of how people have felt the earthquake and on the damage done to buildings and other structures. For example, buildings close to the epicenter of an earthquake often show more damage than buildings that are further away (see table with descriptions below). In Figure 5 you can see that the intensity close to the epicenter of the 1949 earthquake (area in red: shaking was very frightening and damage possible) was much higher than further away (area in grey: shaking was only felt by some).

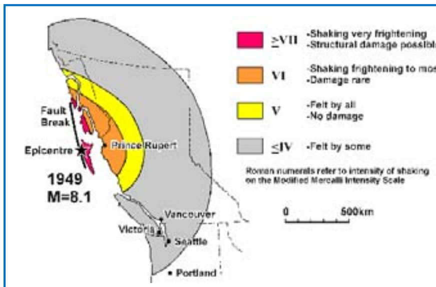

Figure 5. The 1949 Queen Charlotte Earthquake

It is important to note the difference between the total energies given on the magnitude scale, and the felt intensities of the Modified Mercalli Scale. While an earthquake has only one magnitude, it has different intensities in different places.

Earthquake Felt Intensity - The Modified Mercalli Scale

I	Not felt except by very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors, by a few outdoors. At night, some are awakened. Dishes, windows, and doors rattle.

V	Felt by nearly everyone. Many are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.
VII	Most people are in alarm and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially designed structures, considerable in ordinary buildings, great in poorly built structures. Heavy furniture is overturned.
IX	Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.
X	Some well-built wooden structures are destroyed. Most masonry structures destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Virtually total destruction. Waves are seen on the ground surface. Objects are thrown in the air.

Faults

Surface faulting is an obvious hazard to structures built across active faults, such as buildings. In particular, surface faulting can be damaging for structures embedded in the ground (railway and highways) and for buried pipelines and tunnels. Sometimes however, faults are not visible at the surface and only show up after an earthquake has hit. The fault is then visible because the surface on one side of fault is higher than on the other side of the fault. Sometimes the fault offsets a structure built on it, like a fence or a road (Fig. 6).

Figure 6. A fence is offset by the San Andreas fault in California, USA. The line in red shows where the fault runs (Photo: www.smithsonianscience.org).

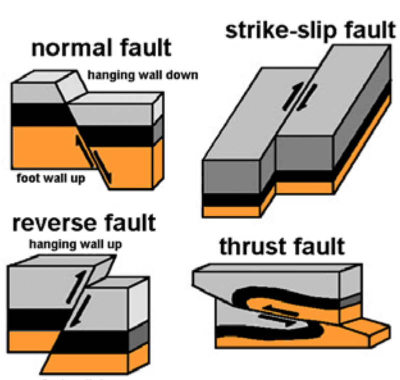

Figure 7. Normal fault, reverse fault, thrust fault and strike-slip fault (Image: www.geologycafe.com).

There are three basic types of fault ruptures (Fig. 7)

- **Normal Faults:** movement is mainly vertical and the rocks above the fault plane move downward in relation to those beneath the fault plane. Most normal faults are often steep, usually between 65 and 90 degrees. Movement along the fault is mostly vertical. Normal faults are commonly visible in the landscape as a cliff or scarp. In a "**Reverse Fault**" the movement is also mainly vertical, but in the opposite direction as in a Normal Fault. Reverse faults are also steep, which sets them apart from Thrust Faults (see below).

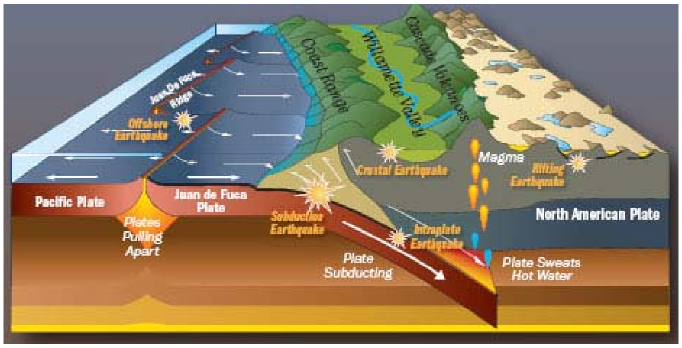

Figure 8 Cascadia Subduction Zone (photo credit Cape Meares Community Association)

- **Thrust Faults:** low angle faults in which the hanging wall has moved up and over the footwall. Movement on a thrust is mostly horizontal (but also vertical), and displacement can be more than 50 kilometers. They are prominent in all of the world's major folded mountain regions. In Canada, the province of British Columbia is at risk of experiencing a "mega-thrust" or subduction earthquake sometime in the (near) future. (See Figure 8). This earthquake could be a very big one, with a magnitude of M8 or M9. However, earthquakes are very hard to predict, and so we do not know when this earthquake could strike, or how big it will really be.

- **Strike Slip Faults:** high angle faults in which movement is horizontal, parallel to the strike of the fault plane. There is little or no vertical movement. Strike-slip faults are expressed in the landscape by a straight, low ridge extending across the surface. Sometimes these faults are not visible at all, and only show up because of displaced fences, roads, etc. (Fig. 6).

Seismic waves

The most important, and most noticed, effect of earthquakes is the violent ground shaking that occurs when there is movement along a fault. "Seismic energy" is released from a fault as "seismic waves." These waves may cause damage to buildings, bridges and other structures near or on the earth's surface. There are 3 types of waves, so-calles "primary," "secondary" and "surface" waves.Each type of wave travels through the earth at a different speed depending on the properties of the wave, and the material (rock, sediment or water) through which it travels.

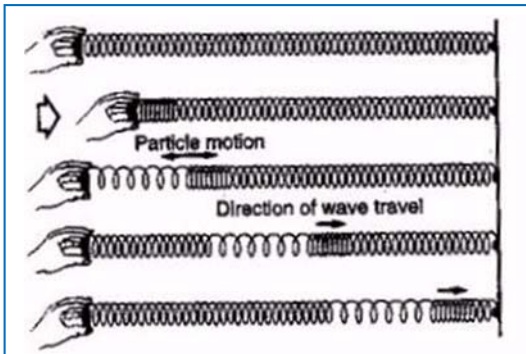

Figure 9. A primary wave travels through the earth similar to a spring being pulled (Image: http://regentsprep.org).

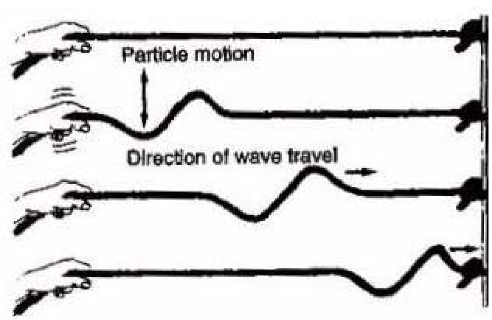

Figure 10. A secondary wave travels through the earth similar to the whipping of a rope (Image: http://regentsprep.org).

The fastest waves are the Primary (P waves) or "compression" waves. Primary waves are the first to arrive at the earth's surface. A primary wave compresses and stretches the rock through which it travels, similar to the way a spring responds to being stretched (see Fig. 9). Primary waves travel in crustal rocks at about five kilometres per second. Next in speed, are Secondary waves (S waves A secondary wave travels mostly in an up and down motion (at a straight angle to the direction the seismic wave travels), similar to the way a rope would respond to the whipping of a rope when held between 2 people (Fig. 10). Secondary waves travel through the earth's crust at about three kilometres per second. Surface waves (also called Rayleigh and Love waves) are the slowest moving, and travel near the surface of the earth with a speed of less than three kilometres per second. Surface waves cause the most damage near the epicenter of the earthquake, because of their complex motion. A surface waves moves similar to an object floating on the ocean, or by a complex horizontal and vertical motion (Fig. 11).

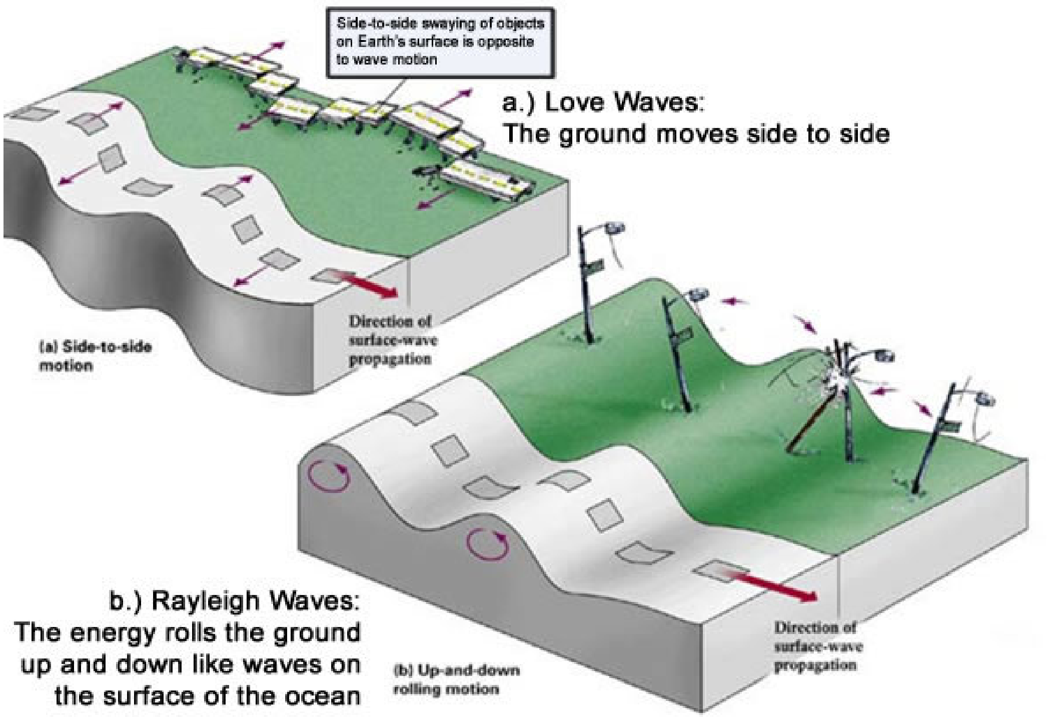

Figure 11. Surface wave motion. Love waves (upper) move mostly in a complex side-ways motion. Rayleigh waves move in a rolling up-and-down motion (Image: www.seismolab.caltech.edu).

It Happened Here…

Naturally Caused Earthquakes

In Langenburg, Saskatchewan (population 1,048) on April 14, 2010 around 12:53 am a magnitude 4.0 earthquake shook the community. No injuries or damages were reported.

In Haida Gwaii, British Columbia (population 948) at 7:30 am on November 17 2009 a magnitude 6.5 earthquake was felt in the community. The lack of damage was believed to be because most buildings were built low-slung resulting in stability during the quake. Another earthquake, with a magnitude of M7.8, hit the Haida Gwaii in on October 27, 2012. Residents experienced strong ground shaking and people moved to higher ground in fear of a minor tsunami the earthquake had generated. The earthquake was also felt on the mainland of British Columbia and led to a loss of electricity in Bella Coola. No major damage or injuries were reported after the quake. However, the hot springs in the Gwaii Haanas National Park dried up after the quake.

On March 16 2011, the ground started shaking and stopped after about 10 seconds in the small community of Grenville, Quebec. The 4.3 quake's epicenter was in Hawkesbury, Ont.

On January 26, 1700 a “mega-thrust” earthquake hit somewhere off the coast of North America. While no modern-day scientific instruments were available to record the earthquake, the event was witnessed and recorded by First Nation communities. The earthquake collapsed houses of the Cowichan people, and caused several landslides.

Liquefaction and Ground Failure Examples

In Larouche, Quebec (population: 1,004) on November 25, 1988 at 11:46pm a magnitude 5.9 earthquake hit the Saguenay region. Liquefaction occurred within near the epicenter of the quake, in which Larouche was located. The earthquake caused tens of millions of dollars of damage to unreinforced masonry structures.

Surface Faulting and Tectonic Deformation Example

In the Inuit community of Kangiqsujuaq, Quebec (population 552) on December 25, 1989, a magnitude 6.3 earthquake caused a 10 km surface rupture in the Ungava Peninsula. It was the first confirmed case of surface faulting in eastern North America and caused changes in land elevation.

Human-caused

Earthquakes in the province of Alberta are rare. In recent years however, small earthquakes (M2-4) have rocked regions in Alberta (for example near Peace River). These small earthquakes have been felt by people in the region, but generally have not caused major damage. The earthquakes are thought to be linked to fracking in the area.

Earthquakes Human-caused

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Seismic activity can cause water level changes in large dams. Is your community located near a large dam?
☐	☐	☐	☐	Deep fluid injection (or fracking), a common practice in oil and gas fields has been associated with seismic activity. Is there an oil and/or gas field located near your community?
☐	☐	☐	☐	Quarrying/ large scale excavations (i.e., mines & tar sands) cause seismic activity due to the removal of large amounts of weight (soil, rock) from the earth’s surface (“crustal unloading”). Is your community located near a quarry mine and/or tar sands field?
☐	☐	☐	☐	Underground nuclear explosions have been associated with seismic activity. Is your community located near sites where underground seismic explosions are carried out?

Earthquake Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	**The best indicator of an earthquake risk is record of them occurring in the past. Does your community have a history of earthquakes? (Check Risk Analysis Resources – Seismic Risk in Canada and Areas of Past Significant Earthquakes in Canada)
☐	☐	☐	☐	**Earthquakes are often located around fault lines. Is your community located near a known fault line? (Check Risk Analysis Resources – Known Major Fault Lines in Canada)

IF YOU HAVE INDICATED THAT YOUR COMMUNITY COULD BE HIT BY AN EARTHQUAKE THEN COMPLETE THE FOLLOWING.

Ground Failure Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	**Reclaimed soils in coastal areas, poorly compacted man-made fill, loose silts & silty sands, and/or deposits such as old or existing water bodies are prone to liquefaction. Is your community located on any of these soils?
☐	☐	☐	☐	**Areas with high groundwater tables are at risk due to the increased chance of water-filled soils which are highly susceptible to liquefaction. Is your community located in an area with a high ground water table? (Check Risk Analysis Resources – Groundwater Location Map) Note that additional research may be required to determine if there is a high ground table in your community.
☐	☐	☐	☐	Lateral spreads occur in areas with little to no slope where liquefaction occurs below the surface layer. Areas that are fairly flat with loose soils below the surface are at risk. Is your community located on a flat area with loose soils below the surface?
☐	☐	☐	☐	Flow failures are liquefaction induced landslides that occur in sloped areas of loose saturated sand or silts. Is your community located on a slope of loose saturated sands or silts?
☐	☐	☐	☐	Sand boils occur when shaking causes subsurface water to rise up through the surface sand. Areas with high ground water tables and sandy surfaces are at risk. Is your community located on a sandy surface with high ground water tables?

Surface Faulting Natural

Hazard Rating	High Risk	☐	Low Risk	☐	Need More Info	☐	Not Applicable	☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Areas located on fault lines are at risk of this “tearing” of the Earth’s surface across a fault. Is your community located on a fault line? (Check Risk Analysis Resources – Known Major Fault Lines in Canada)

Changes in Land Elevation (Tectonic Deformation) - Natural

Hazard Rating	High Risk	☐	Low Risk	☐	Need More Info	☐	Not Applicable	☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Change in land elevation can occur as a result of an earthquake, which can result in a change in slope in the topography. River systems adjust to this by changing course. Areas that have had a change in the course of rivers and/or streams are at risk. Have the river and/or streams in your community changed course recently?

Tsunami

Definition

”Tsunami” is a Japanese word and means “harbour wave.” Tsunami waves are waves that travel in open water invisible for the naked eye. As soon as the tsunami waves approach the shore line, they grow in height and flood the shoreline fast and expectantly. Tsunami waves are normally linked to offshore earthquakes. Tsunamis can also be caused by a large landslide under water, the collapse of a mountain or volcano into the ocean, by a volcanic eruption or a meteorite impact into the ocean.

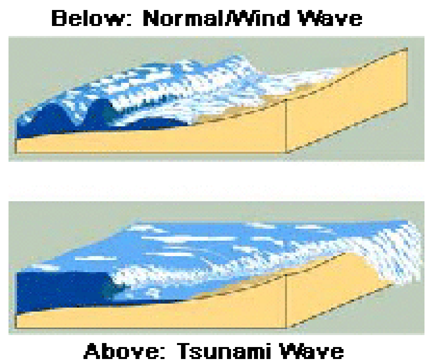

Figure 11 Tsunami Wave

If your community is further than 3.5 kilometers inland or more than 40 meters above sea level then you can safely state that “This couldn’t happen here.”

Discussion

Movement of the ocean floor (sudden sinking (“subsidence”) or uplift) may generate tsunamis, or seismic sea waves. Tsunami waves are extremely wide from wave crest to wave crest. They can travel across the open ocean at high speeds for many thousands of kilometres. As a tsunami approaches the shore, it breaks with tremendous force and can be extremely destructive, especially when it hits an estuary or bay. The advancing wave may crash inland, beaching boats and ships, destroying shoreline facilities and damaging property.

It Happened Here...

Terrenceville, Newfoundland (population 521) is one community affected by the 1929 tsunami that was caused by a submarine landslide, triggered by the Grand Banks 7.2 magnitude earthquake. Twenty-seven people lost their lives as a result of the tsunami and houses, boats, and fish stages were swept away. Damages were estimated around $1M.

In Tofino, British Columbia, the 1960 9.5 magnitude earthquake in Chile caused a 1.2 metre tsunami in Tofino. Damage to log booms was reported.

The mega-thrust, or subduction, earthquake that hit off the coast of North America on January 26, 1700 caused a tsunami that reached as far as the coast of Japan. The tsunami was recorded in Japanese harbor logs, and that is how we know the accurate date of the tsunami. The tsunami also hit the coast of Vancouver Island, it completely wiped out the winter village of the Pachena Bay people.

Tsunamis - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	**Tsunamis are often caused by offshore earthquakes. Areas located near an offshore fault area are at risk. Is your community located on a coast with an offshore fault?
☐	☐	☐	☐	**80% of tsunamis occur in the Pacific Ocean. Coastal areas located along the Pacific Ocean are at risk. Is your community located along the Pacific Ocean?
☐	☐	☐	☐	Areas located in a low lying coastal region, by a bay entrance or near/on tidal flats are at risk. Is your community located in one of these areas?
☐	☐	☐	☐	Areas located near or on the shores of a coastal river or inlet are at risk. Is your community located in one of these areas?
☐	☐	☐	☐	Shoreline tree cover can act as a natural barrier against tsunamis. Areas lacking shoreline tree cover are at risk. Is your community lacking shoreline tree cover?
☐	☐	☐	☐	Reefs can act as a natural barrier against tsunamis. Coastal areas without reefs are at risk. Is your community lacking a reef off the coast?

Volcano - Ash Falls, Projectiles and Lateral Blasts, Pyroclastic Flows and Lava Flows

Definition

A volcano is a vent in the crust of the earth through which molten rock (magma) is reaches the surface of the earth as lava and volcanic debris flows.During a volcanic eruption, volcanic gases and rock fragments are blown into the earth's atmosphere.

There are several volcanic processes that we can distinguish, and each has its own hazards:

- **Ashfall deposits** (also known as pyroclastic air fall or tephra) are tiny, very fine rock fragments which have been ejected, more or less vertically, from a volcano and have then fallen back to earth.
- **Pyroclastic flows** are mixtures of hot gases, ash, fine pumice and rock which are travel down the slopes of volcanoes with great speed (up to 700 km/hour).
- When magma reaches the surface it is called **"lava."** The lava is a fluid rock melt , which can contain suspended crystals, dissolved gasses and liquids.Lava reaches the surface of the earth via a volcanic eruption.
- A **volcanic blast** is one of the most explosive volcanic eruptions, during which part of the volcano is blown away. It is most destructive when accompanied by a pyroclastic flow.
- **Projectiles** are lethal rock fragments of varying sizes that are violently ejected from a volcano.
- **Mudflows** or "**lahars**" are slurries of jumbled, solid volcanic rock fragments mixed with water, and while some mudflows may be hot, most occur as colds flows. These mudflows or lahars occur mostly on volcanoes with a snow and/ or ice cap. The heat from the volcanic eruption melts the snow or ice, and then forms these dangerous mudflow mixtures.

Discussion

There are two main types of volcanoes, the "shield volcano" and the "strato or composite volcano." There are other volcano types, such as volcanic domes, cinder cones which can be found in Canda and those located in rift zones which are only found offshore from Canada.

Shield volcanoes are the largest volcanoes on earth. The slopes of these volcanoes are often very gentle, and the volcano resembles an up-side-down warrior shield (Fig. 12 and 13). Eruptions from shield volcanoes are not very violent. Lava usually flows gently down the slopes of the volcano. Mauna Loa on the big island of Hawaii is the largest (shield) volcano on earth. From

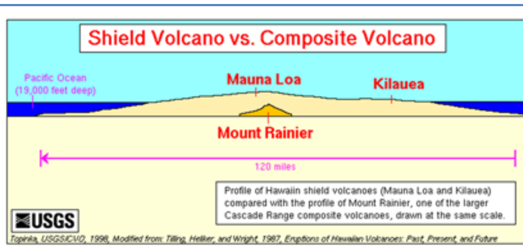

Figure 12. The profiles of Mauna Loa (a shield volcano) versus Mount Rainier (a strato or composite volcano: Image: http://usgs.com)

Figure 13. Mauna Loa as seen from the air (Photo: www.wikipedia.com)

the base of the volcano at the bottom of the ocean, to the top of the volcano Mauna Loa measures over 9 kilometers high (higher than Mount Everest).

Figure 14. A view of Mount Rainier (strato volcano; Photo: www.dnr.wa.gov).

A strato volcano (or composite volcano) is what many people consider as a “text book” volcano (Fig. 14). It has steep slopes, and it very often displays a white snow cap. Strato volcanoes erupt more violently then shield volcanoes, some eruptions are true explosions. These volcanoes emit lavas as well as pyroclastic flows. Lahars can occur when the volcano has an snow or ice cap. Many of the Cascade volcanoes in the Pacific Northwest are strato volcanoes, such as Mount St. Helens and Mount Rainier in the USA, and Mount Meager and Mount Garibaldi in British Columbia.

Six volcanic belts categorize the Canadian volcanoes less than 5 million years old: Anahim Volcanic Belt, Chilcotin Plateau Basalts, Garibaldi Volcanic Belt, Stikine Volcanic Belt, Wells Gray Clearwater Volcanic Field and the Wrangell Volcanic Belt.The potential destructiveness of a volcano depends to a great degree on the kind of lava it emits and by the manner of its eruption. Violent strato volcanoes produce the stiffest lava and send up great clouds of fine ash in a “cauliflower” cloud which disperses across large areas by wind. The most destructive volcanos, send out dense clouds of gases and material, the so-called pyroclastic flows, which tumble over the edge of the crater and roll rapidly down the slope.

During an explosive eruption, a volcano may produce a large plume composed of ash, gases and other volatile materials. These ashes can travel for hundreds of kilometres and cover areas at great distances from the volcanic source. The ashes pose serious public health hazards especially in settlements located downwind from the volcano. Fine ash particles may be inhaled deep into the lungs creating or making worse a variety of respiratory problems, such as asthma and bronchitis.Courser particles can lodge in the nose, causing extreme irritation, or in the eyes, resulting in scratches on the outer layer of the eye (the “cornea”). Heavy ash deposits may destroy agriculture, pollute water supplies, disrupt transportation and communication facilities, and collapse buildings and other structures. These effects can have a big influence on the local or regional economy, as farmers may not be able to harvest crops, or fish may die as the waters are polluted by ashfall.

Pyroclastic flows travel at speeds –up to 700 kilometres per hour.Since pyroclastic flows consist of hot air, ashes, rocks, and gasses they are very powerful and destroy everything in their way. Humans are typically unable to outrun a pyroclastic flow, and they are known to cause suffocation, inhalational injuries and burns.

Two types of lava flows are generally recognized and they are linked to the 2 main types of volcanoes. “Non-sticky” or “fluid” lavas are linked to shield volcanoes, also known as “low viscosity” lavas. “Sticky” or less fluid lavas are linked to strato (or composite) volcanoes, and are also known as “high viscosity” lavas. Low viscosity lavas are typical of the less violent eruptions and have higher rates of movement and can travel great distances. High viscosity lavas are typical of the more explosive volcanoes such as the composite cones of the Cascade Range. Lava flows from these volcanoes tend to move at lower velocities and travel shorter distances. Although lava flows may be very destructive of property, water supply reservoirs and agricultural lands in their paths, they rarely travel fast enough to endanger human life directly.

Volcanic blasts can produce noise which may be heard over long distances. It may also shatter windows and other glass-like structures, leading to glass cuts to the skin. Volcanic projectiles may damage houses, bridges and other human- made structures as well as start fires if hot enough.

Mudflows or “lahars” move downhill and tend to follow topography, such as ridges or river stream. Mudflows may fill rivers and lakes and cause flooding, as well as change the levels and courses of existing rivers. Mudflows may bury and destroy facilities such as highways and forest roads, and destroy reservoirs. Mudflows are most likely to occur on the more explosive strato volcanoes; almost all of the Cascade composite volcanoes have had numerous mudflows during the past 10,000 years.

Even though there have not been any lahars recorded in Canada in recent times they are not outside the realm of possibility because many of the volcanoes located throughout Western Canada are active though dormant (or “sleeping”). Past eruptions by Mount Meager, British Columbia, have resulted in lahars that reached far into the Lillooet River valley to areas that are currently inhabited or used for agriculture and recreation. If this were to occur today there would be lives lost and large damage costs to buildings and infrastructure in the region. The last eruption of Mount Meager occurred 2350 years ago, and this was a very violent eruption. Pyroclastic flow deposits have been found in the valley. These pyroclastic flows are thought to have blocked the valley and led to flooding of the Lillooet River.

Pyroclastic flow deposits have also been found at Hoodoo Mountain and Mount Edziza in British Columbia.

It Happened Here…

Lava flow

Around1750 approximately 2,000 members of the Wil Lax L’abitan Lax Ksiluux First Nation communities perished during the eruption of the Nisga’a Tseax Cone volcano. It is believed to be the last volcanic eruption and lava flow in the province of British Columbia. The Nsiga’a Memorial Laval Beds Provincial Park now lies there.

Ash Falls

On June 27, 1992, Mount Spurr erupted in Alaska, affecting Hanes Junction, Yukon (population 589). Enough ash was deposited in the Yukon area around Hanes Junction to close the Alaska Hwy for a few hours because of reduced visibility.

Volcano Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	**Your community is at risk if it is located near a volcano. Is your community located near a volcano? (Check Risk Analysis Resources – Major Volcanoes)
☐	☐	☐	☐	Volcanoes can lie dormant (“sleeping”) for hundreds or even thousands of years. Seismic activity around dormant volcanoes can signal their awakening. Areas experiencing earthquakes near dormant volcanoes are at risk. Is your community near a dormant volcano AND experiencing seismic activity?

IF YOU HAVE INDICATED THAT YOUR COMMUNITY COULD POTENTIALLY BE AFFECTED BY A VOLCANIC ERUPTION THEN COMPLETE THE FOLLOWING.

Ash Falls - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	**Ash falls are typical characteristics of volcanoes with violent eruptions. Areas near volcanoes known to have explosive eruptions, such as the Cascade Range, are at risk. Is your community located near known explosive volcanoes? (Check Risk Analysis Resources - Major volcanoes in Canada)
☐	☐	☐	☐	Fertile grounds near volcanoes are often evidence of previous ash falls. Fertile areas near volcanoes are at risk. Is your community situated on or near fertile grounds?
☐	☐	☐	☐	Areas downwind of volcanoes are at greater risk of ash falls because the ejected ashes can be carried by the wind. Is your community located downwind of a volcano (the dominant high atmosphere wind direction in Canada is west to east)?
☐	☐	☐	☐	Ash fall is heaviest closer to the eruption site (volcano crater) because denser and heavier ash begins to fall first. Areas close to a potential eruption site are at risk. Is your community located in close proximity to a volcano (less than a kilometer)?

Lava Flows Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Very thick, sticky (high viscosity) lava produced by violent eruptions of strato volcanoes travel slower and less distance than fluid, less sticky lava from shield volcanoes. Areas **close** to these strato volcanoes are at risk. Is your community located at the foot of a **strato** volcano? (Check Risk Analysis Resources Major volcanoes in Canada)
☐	☐	☐	☐	Fluid, less sticky lavas (low viscosity) produced by less violent eruptions from shield volcanoes travel faster and farther than lavas from strato volcanoes. Areas in a **wide area** around these **shield** volcanoes are at risk. Is your community located in visual distance from a volcano?

Mudflows Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	**Mudflows are most commonly associated with explosive strato volcanoes, such as those in the Cascade Range. Areas near known explosive volcanoes are at risk. Is your community located near a composite cone volcano? (Check Risk Analysis Resources - Composite Cone Volcano)
☐	☐	☐	☐	**Mudflows are a combination of volcanic rock and water. Areas near volcanoes with glaciers, snow caps and/or crater lakes are at risk. Does the volcano near your community have glaciers, snow caps and/or crater lakes?
☐	☐	☐	☐	Mudflows often follow the topography. Areas downhill from volcanoes, along ridges or stream drainages or in river valleys are at risk. Is your community located downhill from a volcano, along a ridge, stream drainage or in a river valley?
☐	☐	☐	☐	Slopes and hillsides near active volcanoes can build up volcanic materials after an eruption. Rainfall can trigger these materials to flow downstream. Areas located on or below slopes that can potentially buildup with volcanic material are at risk. Is your community located below slopes near a volcano?
☐	☐	☐	☐	Curving inward (concave) slopes are more likely to collect volcanic material and water. This results in saturated volcanic deposits which can trigger a slide. Areas with concave slopes are at risk. Are the slopes around your community concave?

Projectiles and Lateral Blasts - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Volcanic projectiles and lateral blasts are characteristics of explosive-type volcanoes. Areas located near these volcanoes are at risk. Is your community located near an explosive-type (strato) volcano? (Check Risk Analysis Resources - Major volcanoes in Canada)
☐	☐	☐	☐	Lateral blasts can trigger a tsunami if the volcanic material hits water. Areas located on bodies of water which are also bordered by volcanoes are at risk. Is your community located near a body of water that has a volcano next to it?

Pyroclastic Flows - Natural

Hazard Rating	High Risk ☐	Low Risk ☐	Need More Info ☐	Not Applicable ☐

Yes	No	Need More Info	Not Applicable	FACTORS
☐	☐	☐	☐	Pyroclastic flows are “clouds” of hot ash, gases and rocks that flow down the sides of a volcano. Areas located on or below the slopes of a dormant (“sleeping”) or active volcano are at risk. Is your community located on or below the slopes of a volcano?
☐	☐	☐	☐	Pyroclastic flows are a characteristic of destructive volcanoes. Areas with violent volcanoes are at risk. Is your community located near a violent volcano (i.e., strato volcano)?
☐	☐	☐	☐	Pyroclastic flows are common during violent volcanic eruptions. These typically occur in strato volcanoes along the West Coast of Canada (Cascadia Volcanic Range). Is your community located in Western Canada AND near a strato volcano?
☐	☐	☐	☐	Pyroclastic flows have been known to travel over water. Areas located across bodies of water from volcanoes are at risk. Is your community located near a body of water that has a volcano next to it?
☐	☐	☐	☐	Pyroclastic flows often follow the topography. Areas downhill from volcanoes, along ridges, stream drainages, or in river valleys are at risk. Is your community located downhill from a volcano, along a ridge, stream drainage or in a river valley?

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