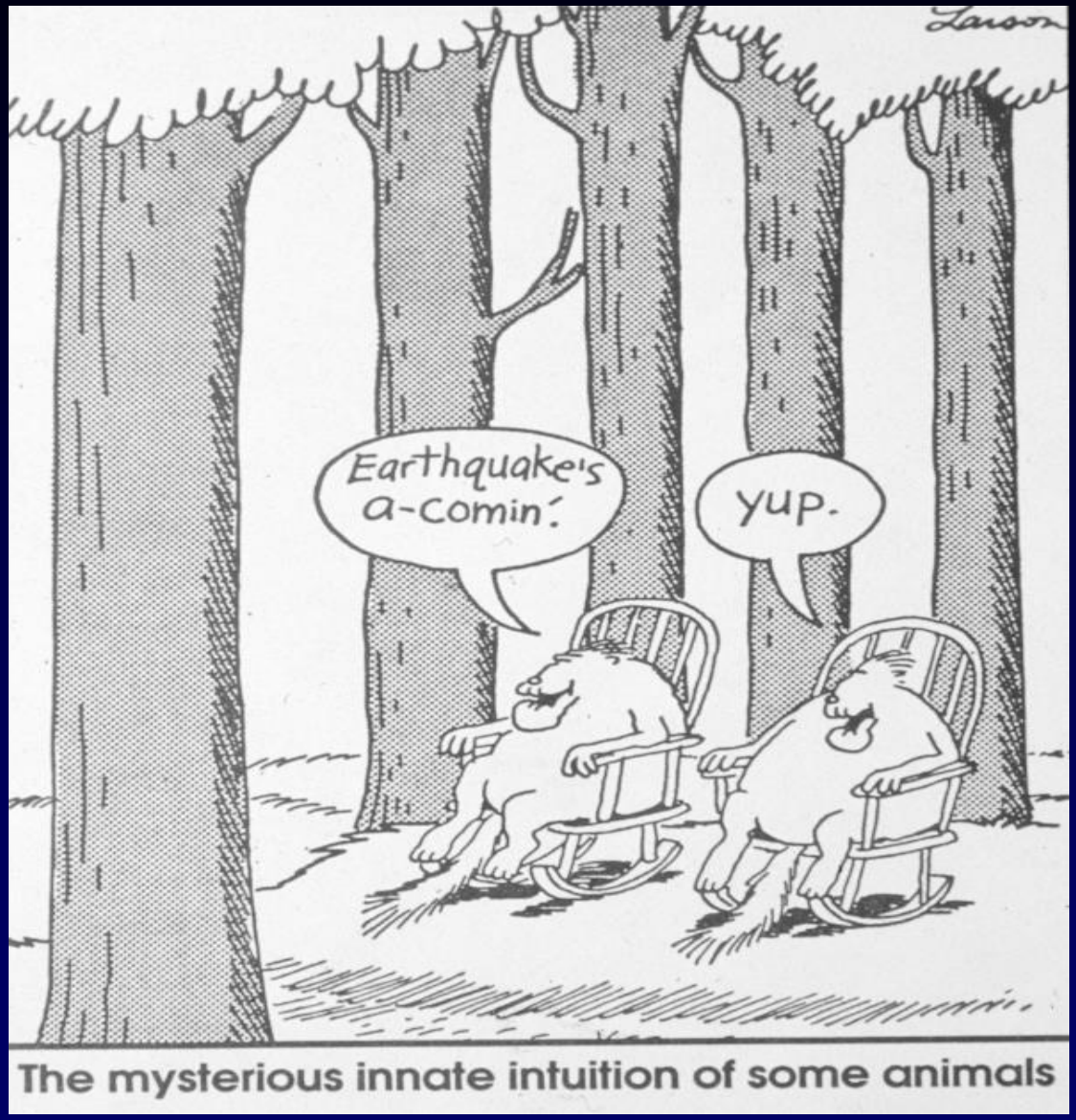
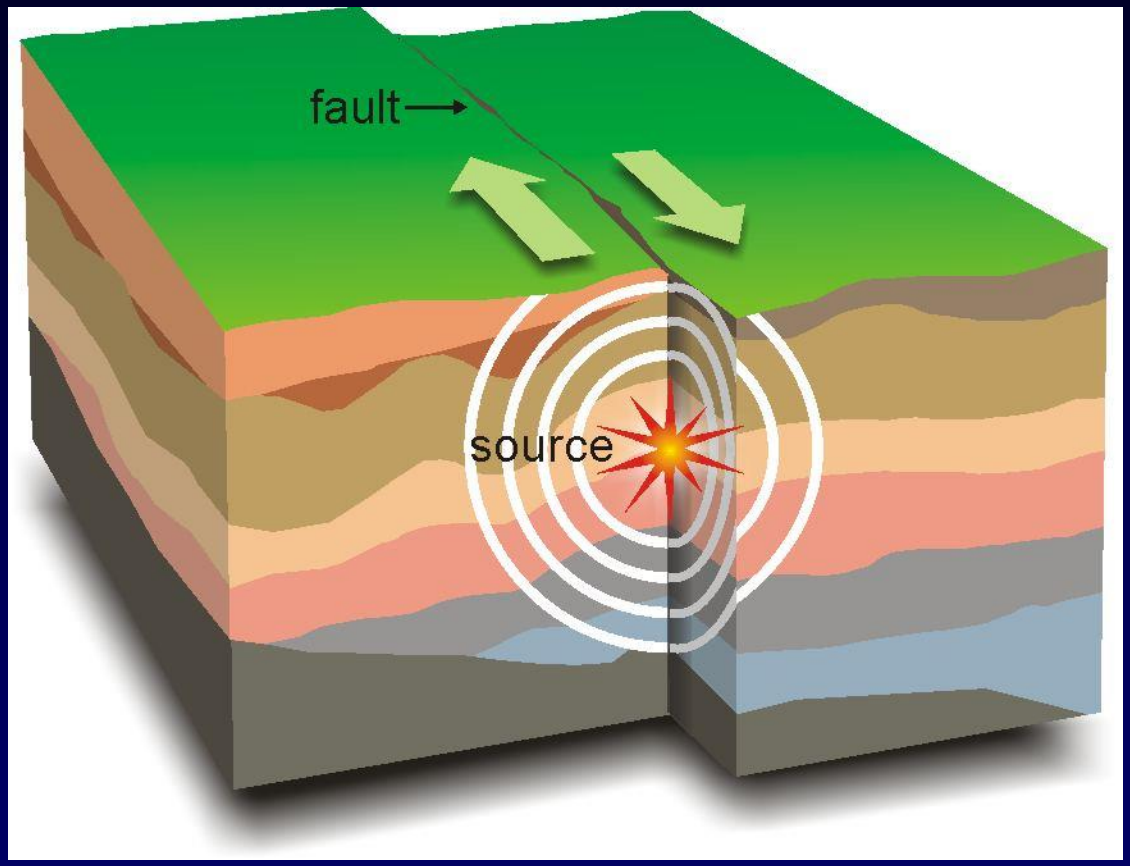
Earthquakes on Canada's West Coast

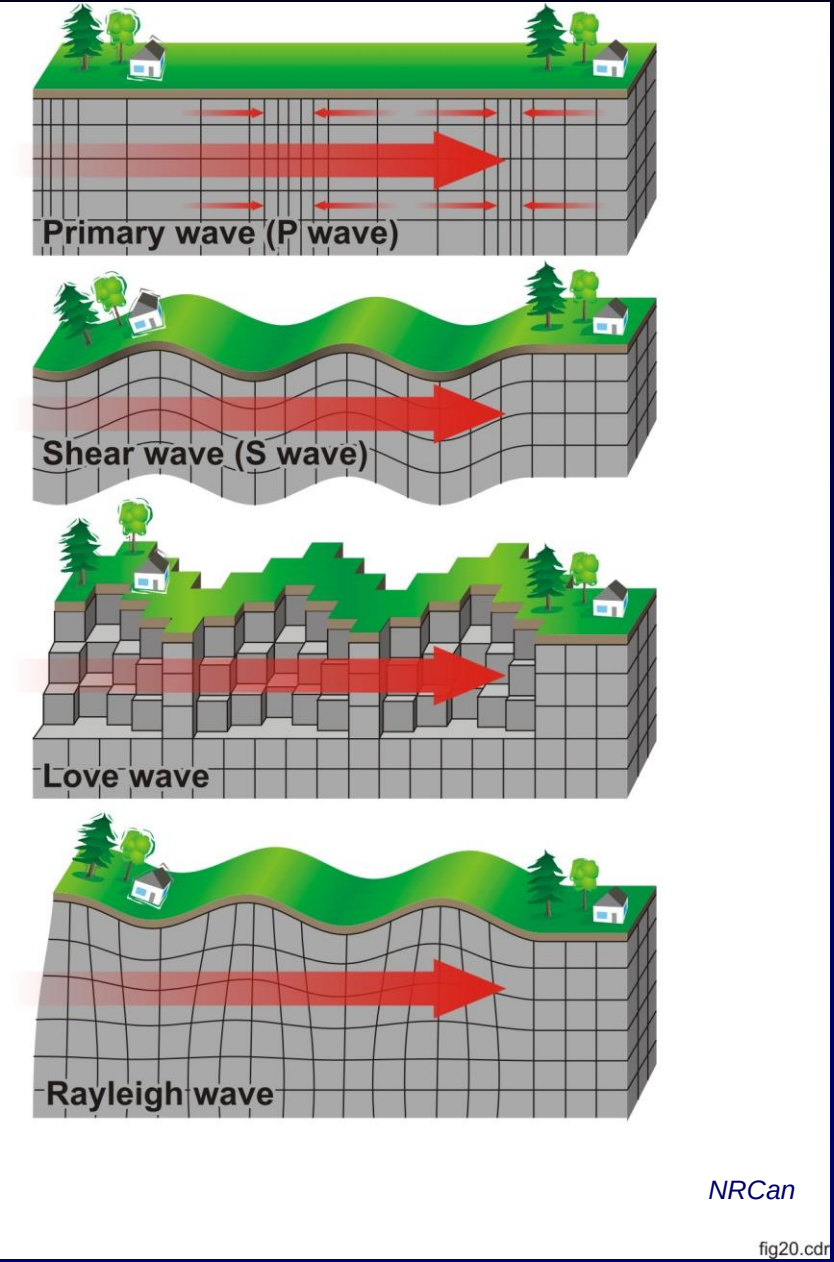


John J. Clague
SFU Centre for Natural Hazard Research

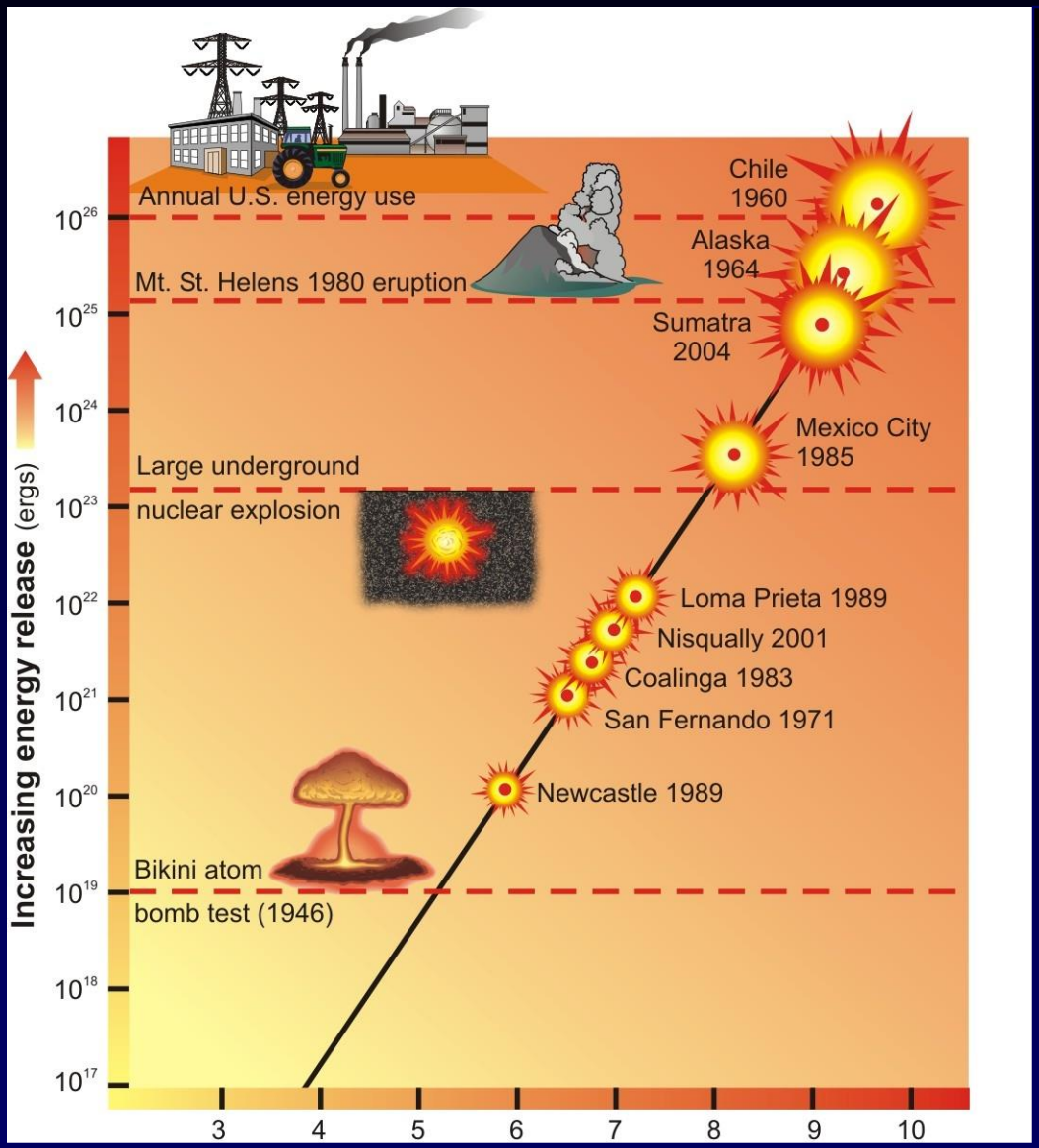
What is an earthquake?



A ‘discordant symphony’ of energy…



What is earthquake magnitude? …



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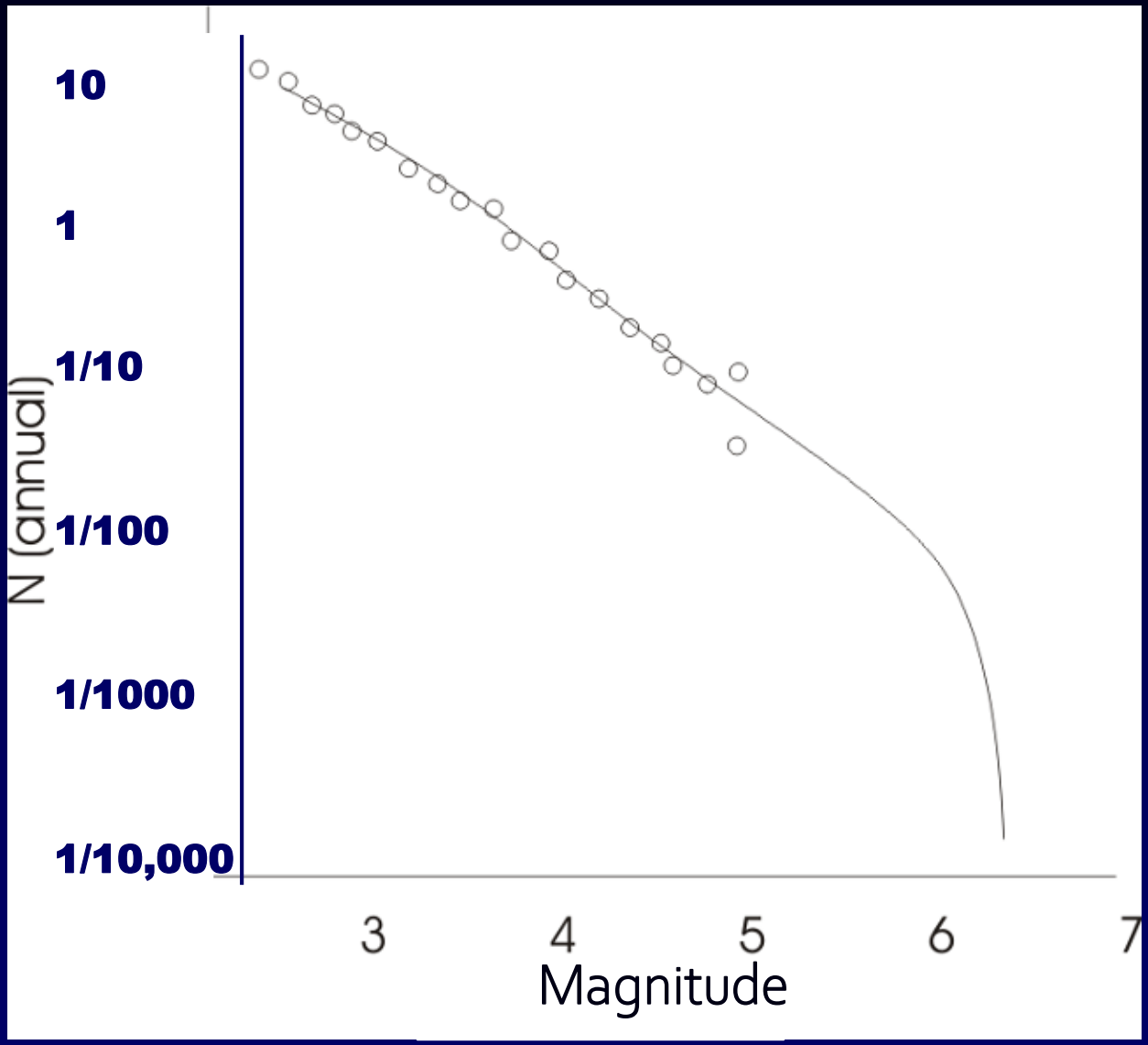
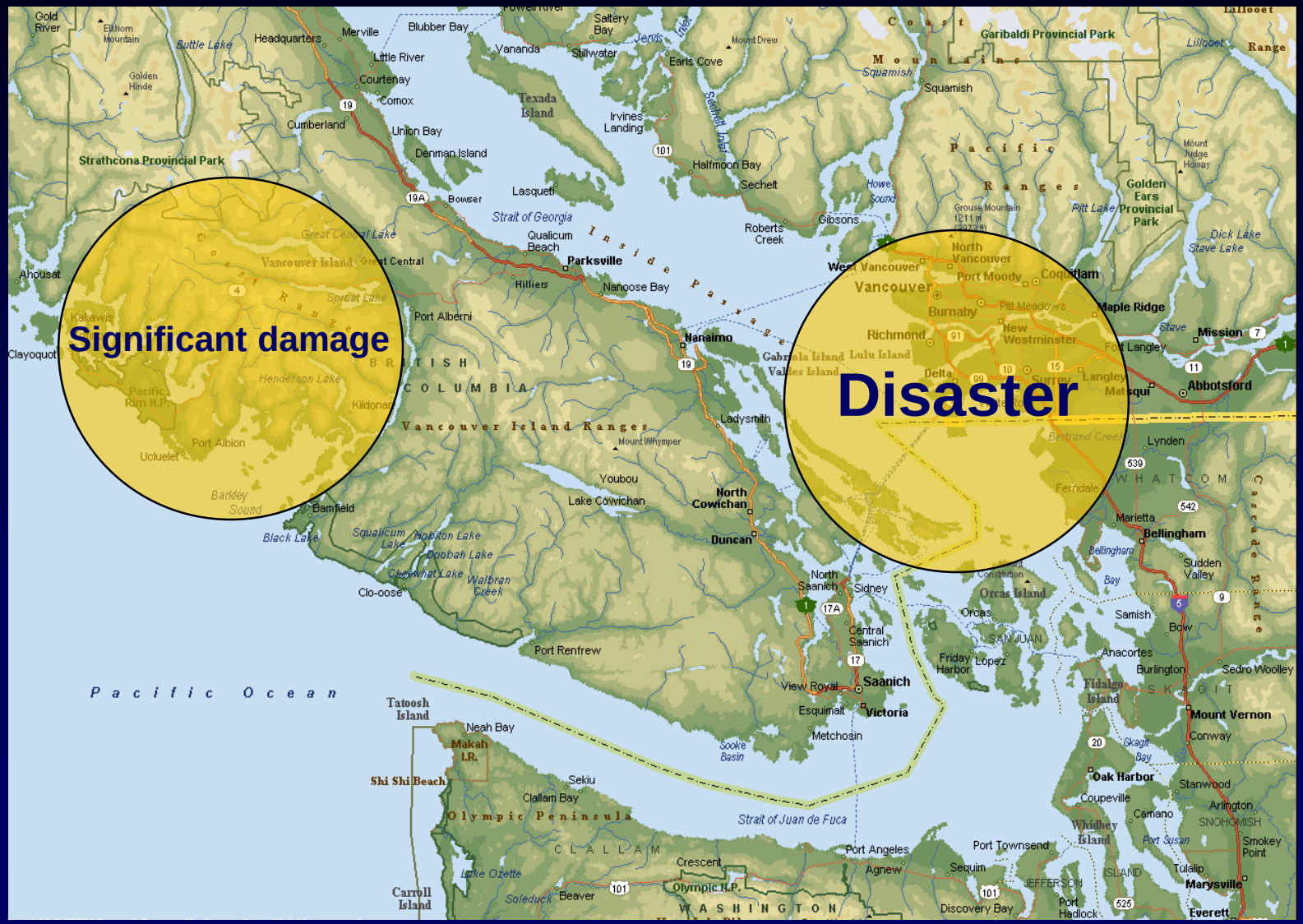
Frequency - magnitude concept

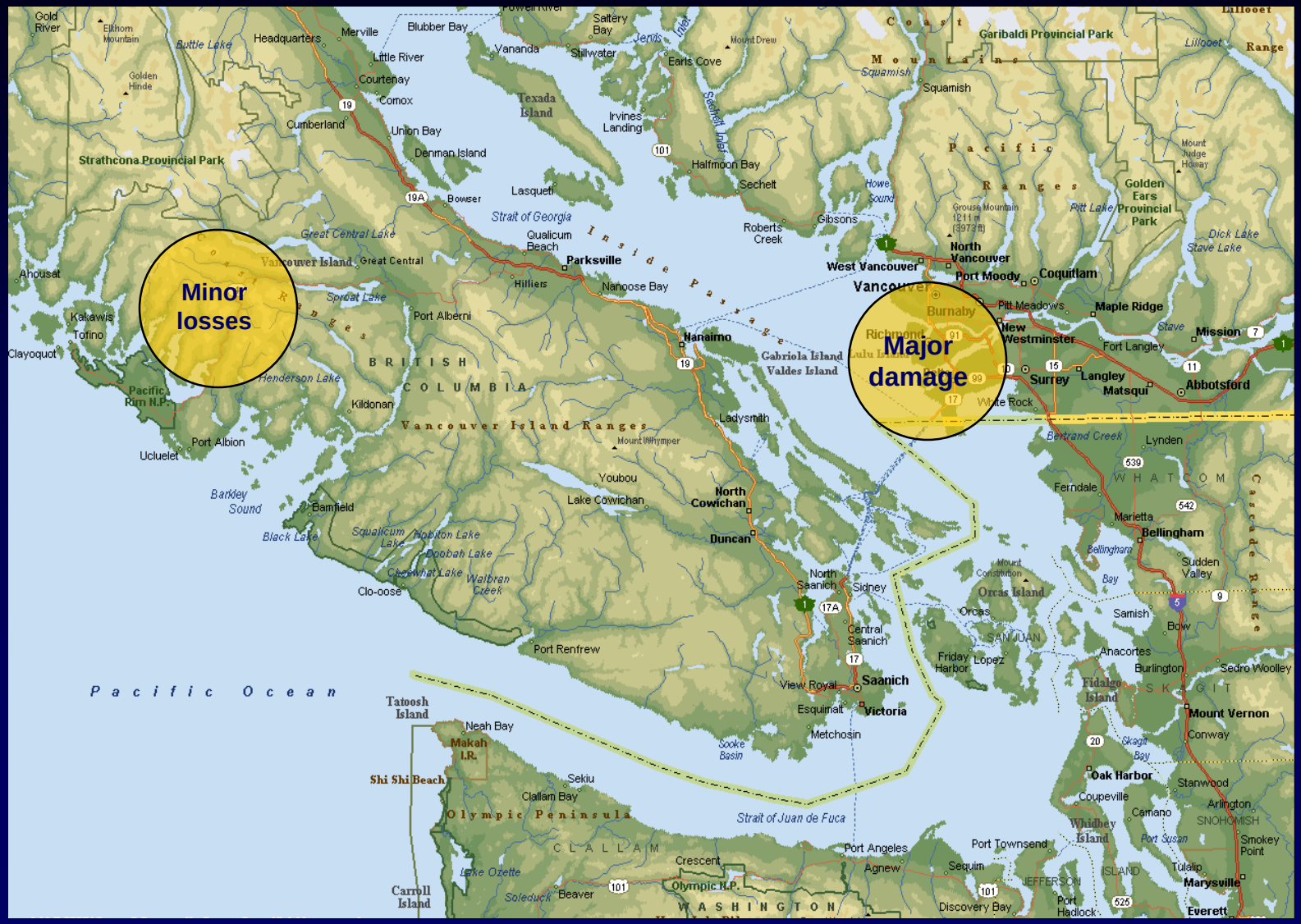


As in real estate, it's location, location, location! …

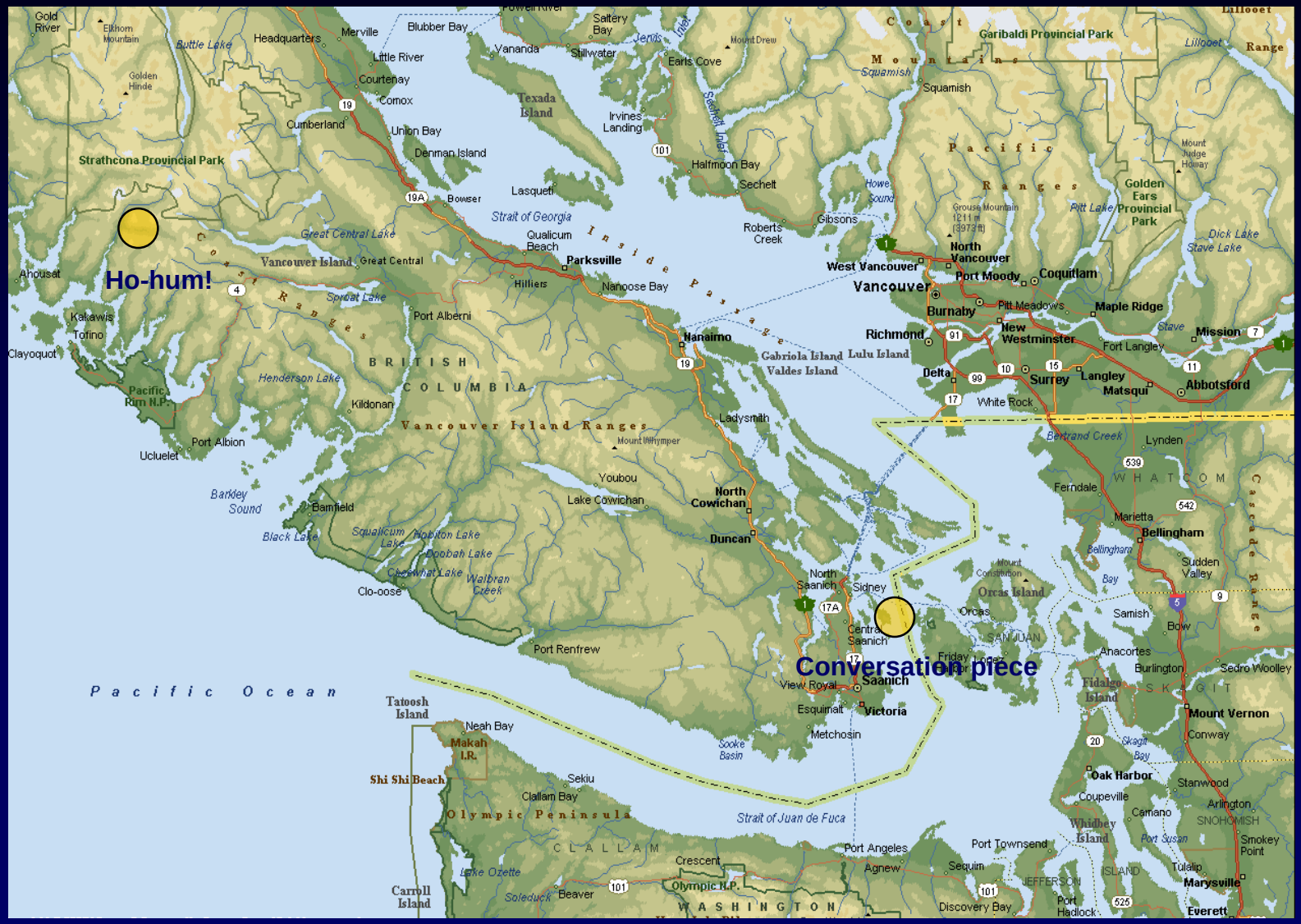
Magnitude 7



Magnitude 6


Minor losses
Major damage
Strait of Georgia
Inside Passage
Vancouver Island Ranges
Coast Mountains
Pacific Ranges
Olympic Peninsula
Strait of Juan de Fuca
Pacific Ocean
BRITISH COLUMBIA
WASHINGTON
Vancouver
Victoria
Nanaimo
Parksville
Duncan
Saanich
Bellingham
Mount Vernon
Everett
Marysville
Abbotsford
Mission
Langley
Surrey
Coquitlam
Port Moody
North Vancouver
West Vancouver
Squamish
Garibaldi Provincial Park
Strathcona Provincial Park
Golden Ears Provincial Park
Pacific Rim N.P.
Olympic N.P.
Gabriola Island
Valdes Island
Orcas Island
San Juan Island
Whidbey Island
Fidalgo Island
Tatoosh Island
Carroll Island
Texada Island

Magnitude 4


Ho-hum!
Conversation piece
Strait of Georgia
Inside Passage
Vancouver Island
Vancouver
Victoria
Pacific Ocean
Strait of Juan de Fuca
Olympic Peninsula
Strathcona Provincial Park
Garibaldi Provincial Park
Golden Ears Provincial Park
Pacific Rim N.P.
Olympic N.P.
Texada Island
Gabriola Island
Valdes Island
Lulu Island
Orcas Island
Whidbey Island
Fidalgo Island
Tatoosh Island
Carroll Island
Parksville
Nanaimo
Duncan
North Cowichan
Ladysmith
Port Alberni
Tofino
Ucluelet
Port Renfrew
Sooke Basin
Saanich
Sidney
Victoria
Vancouver
West Vancouver
North Vancouver
Burnaby
Richmond
Delta
Surrey
Langley
Coquitlam
Port Moody
Maple Ridge
Mission
Abbotsford
Bellingham
Mount Vernon
Everett
Port Angeles
Port Townsend
Oak Harbor
Squamish
Whistler
Powell River
Courtenay
Comox
Campbell River
Port Hardy
Port Alberni
Nanoose Bay
Qualicum Beach
Lasqueti
Denman Island
Hornby Island
Galiano Island
Mayne Island
Pender Island
Saltspring Island
Salt Spring Island
Sechelt
Gibsons
Roberts Creek
Halfmoon Bay
Earls Cove
Vancouver Island Ranges
Coast Mountains
Pacific Ranges
Olympic Peninsula
Great Central Lake
Sproat Lake
Henderson Lake
Barkley Sound
Nootka Sound
Clayoquot Sound
Kakawis
Ahousat
Port Albion
Bamfield
Kildonan
Youbou
Lake Cowichan
Cowichan Lake
Shawnigan Lake
Sooke Lake
Neah Bay
Sekiu
Clallam Bay
Port Angeles
Port Townsend
Sequim
Discovery Bay
Port Hadlock
Oak Harbor
Coupeville
Camano
Stanwood
Arlington
Marysville
Tulalip
Smokey Point
Everett
Mount Vernon
Conway
Sedro Woolley
Burlington
Anacortes
Friday Harbor
Orcas
Sidney
Central Saanich
North Saanich
Esquimalt
View Royal
Metchosin
Sooke
Lake Ozette
Soleduck
Beaver
Crescent
Agnew
Port Moody
Pitt Meadows
Maple Ridge
Fort Langley
Langley
Matsqui
White Rock
Ferndale
Lynden
Marietta
Sudden Valley
Bow
Samish
Bellingham Bay
Skagit Bay
Port Susan
Stave Lake
Pitt Lake
Howe Sound
Squamish
Lillooet
Lillooet Range
Mount Drew
Mount Whymper
Mount Constitution
Grouse Mountain
Mount Judge Holway
Dick Lake
Bertrand Creek
Saltery Bay
Jervis Inlet
Sechelt Inlet
Texada Island
Irvines Landing
Union Bay
Cumberland
Merville
Little River
Headquarters
Blubber Bay
Vananda
Stillwater
Bowser
Hilliers
Great Central
Golden Hinde
Elkhorn Mountain
Buttle Lake
Gold River
Tatoosh Island
Makah I.R.
Shi Shi Beach
Clallam Bay
Crescent
Olympic N.P.
Port Angeles
Port Townsend
Sequim
Discovery Bay
Port Hadlock
Everett
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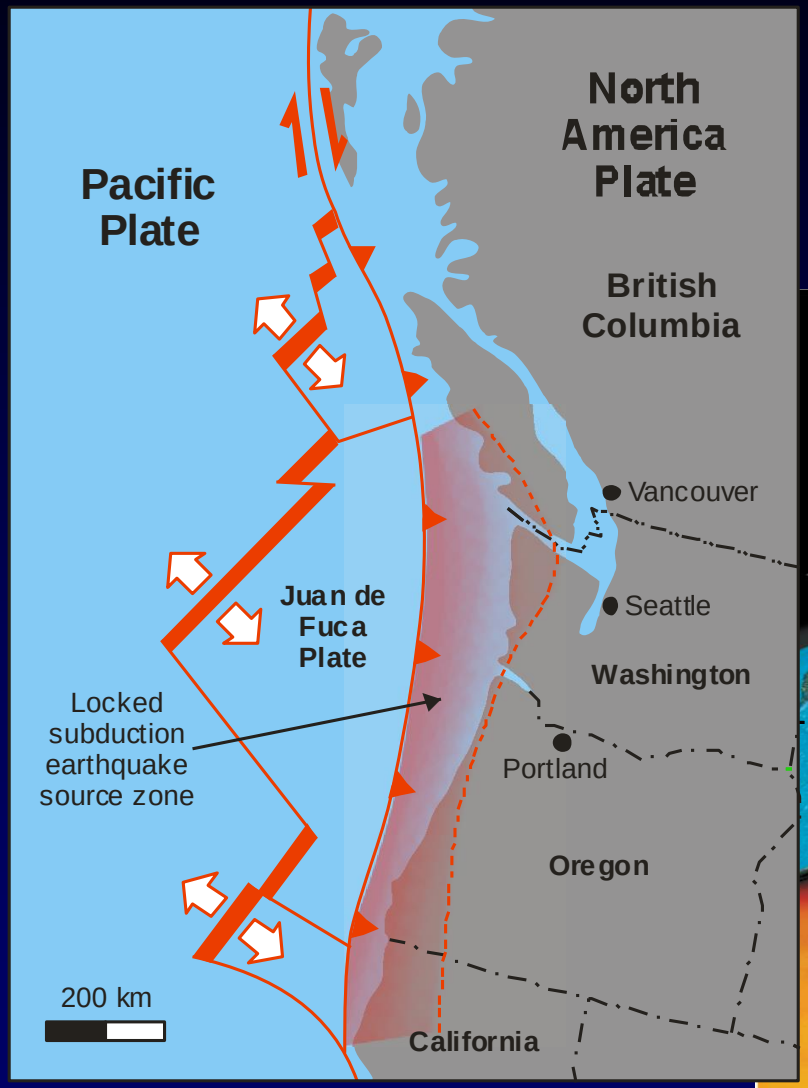
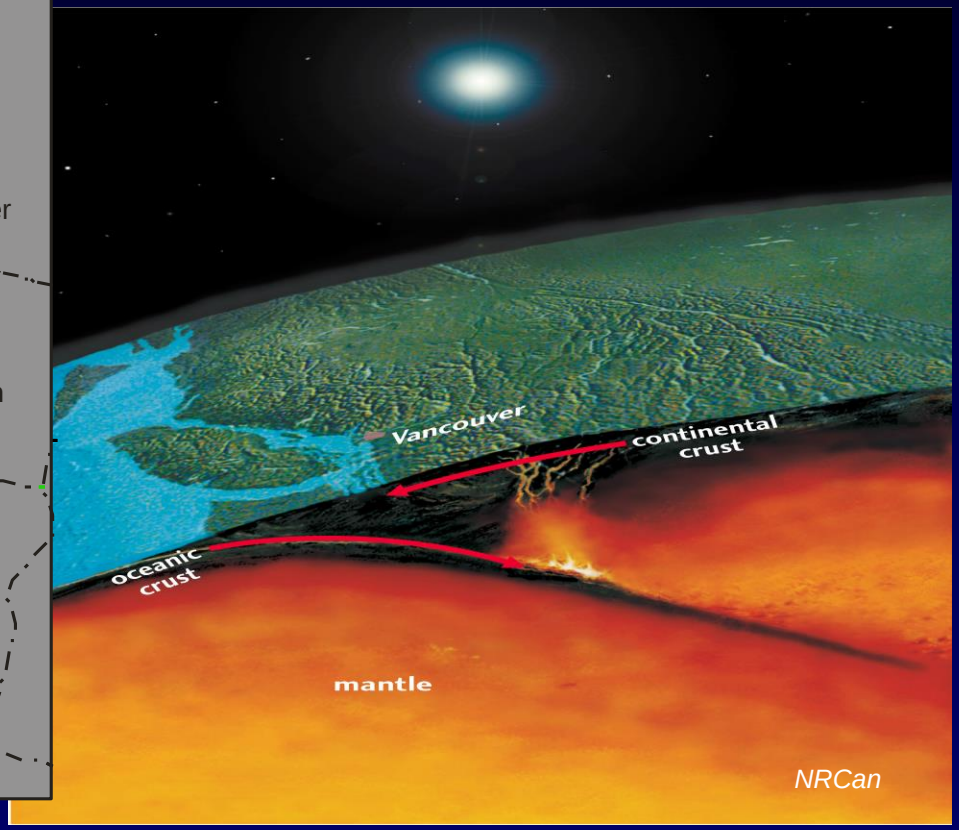
Coupeville
Camano
Stanwood
Arlington
Marysville
Tulalip
Smokey Point
Everett

Why do we have earthquakes?





Historic earthquakes

TODAY: PART 1 OF AN INVESTIGATIVE REPORT ON A B.C. SERIAL RAPIST AND KILLER

THE VANCOUVER SUN

www.vancouversun.com FINAL 5 THURSDAY, MARCH 1, 2001

Richter 6.8

'The magnitude of this quake is a wake-up call to B.C.'

ANTHONY P. BOLANTE/REUTERS

The serious damage in Wednesday's earthquake took place south of the border. Here, Kristi Helm of Seattle reacts outside the Starbucks corporate headquarters building in downtown Seattle.

By LORI CULBERT

A powerful earthquake rocked the West Coast Wednesday, causing extensive damage in the Pacific Northwest and sending out shockwaves that were felt from British Columbia to Utah.

In Seattle and Olympia, the hardest hit areas, the quake that measured 6.8 on the 10-point Richter scale sent high-rise office towers into a terrific

earthquake zone in Canada.

"The magnitude of this happening in this vicinity is a wake-up call to all of us," said Cathi Piazza, of the Provincial Emergency Centre.

"At this point, the reports coming in show no death or injuries or damage in B.C."

South of the border was another matter. The strongest quake to hit Washington state in 52 years tem-

restaurant in Everett, 50 kilometres north of Seattle. "Then the ground started moving around."

Washington Governor Gary Locke, who said books and pictures were knocked off the walls at the governor's mansion, declared a state of emergency, freeing state resources and clearing the way to seek federal aid. Similar declarations were made by Seattle leaders.

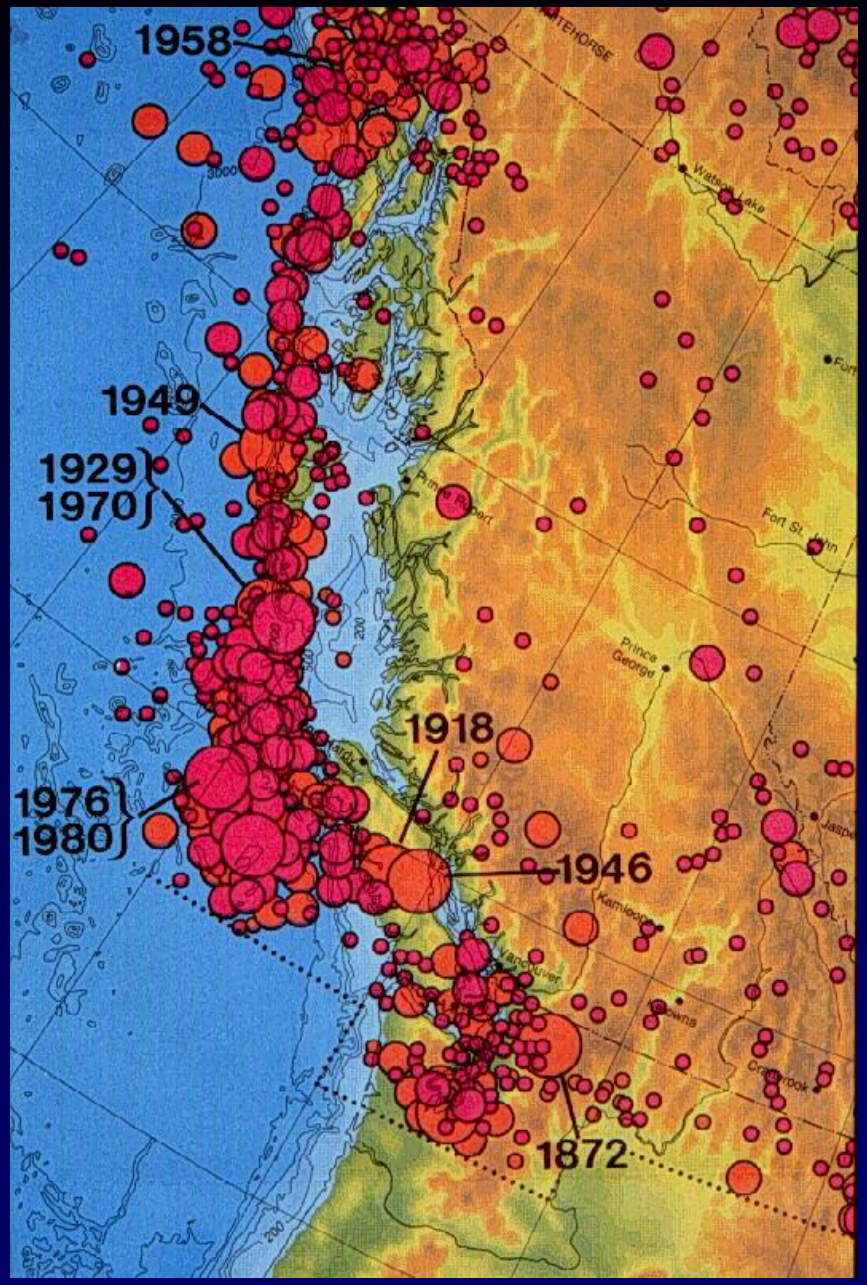
— bigger than six on the scale — to cause damage in the last 120 years.

The most recent serious quake in B.C. was a 7.3 event, the largest onshore quake in Canadian history, in June, 1946 near Courtenay, which killed one person and caused extensive property damage.

Experts in Vancouver estimate that Wednesday's tremors, by the time they reached Vancouver were

RICHTER 6.8

Size matters: It was a big earthquake, but not the big one. A3



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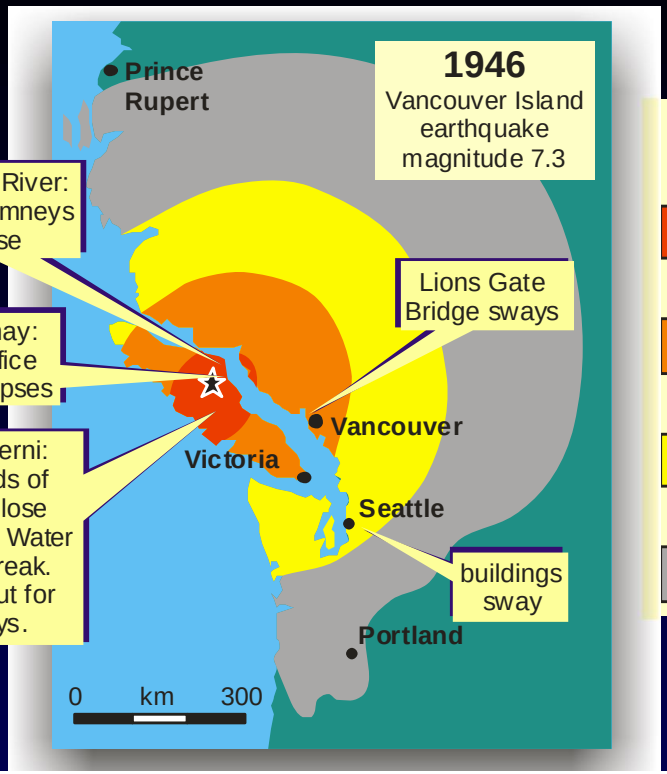
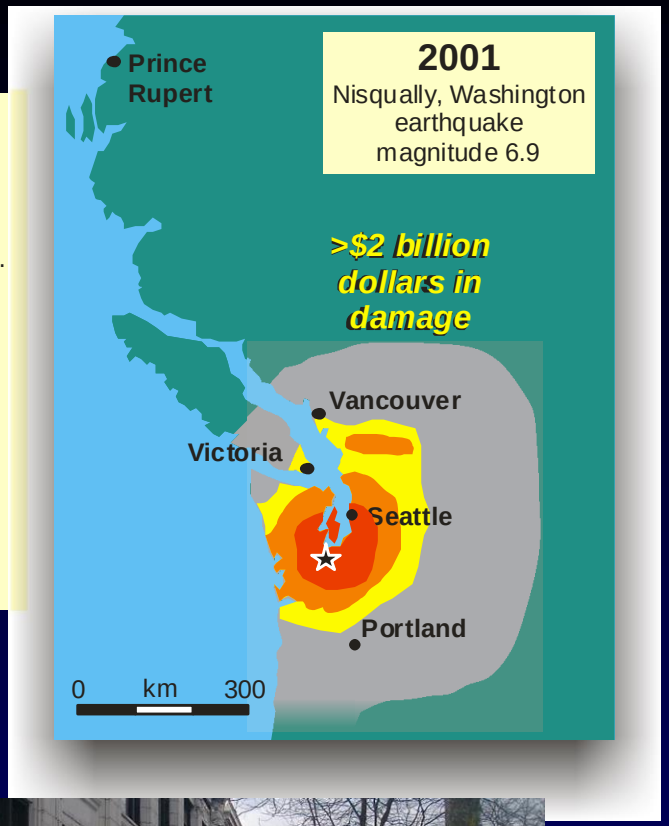
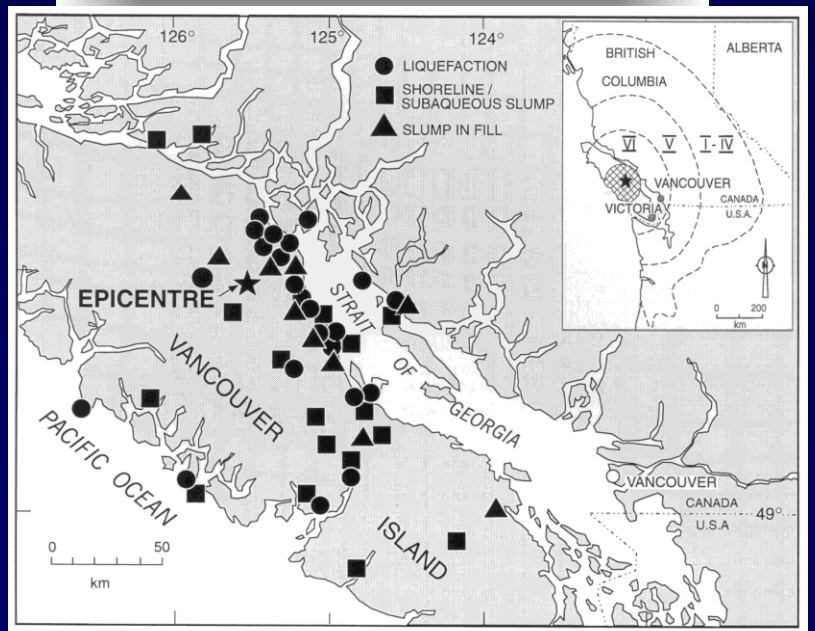
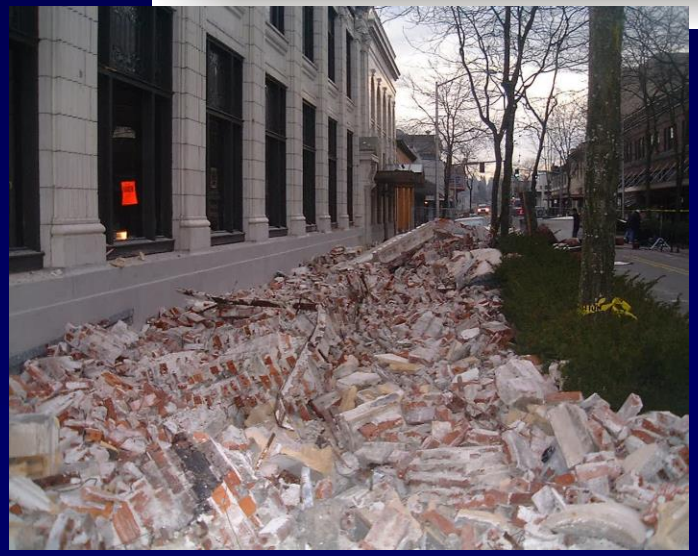


Shake maps (Mercali intensity)

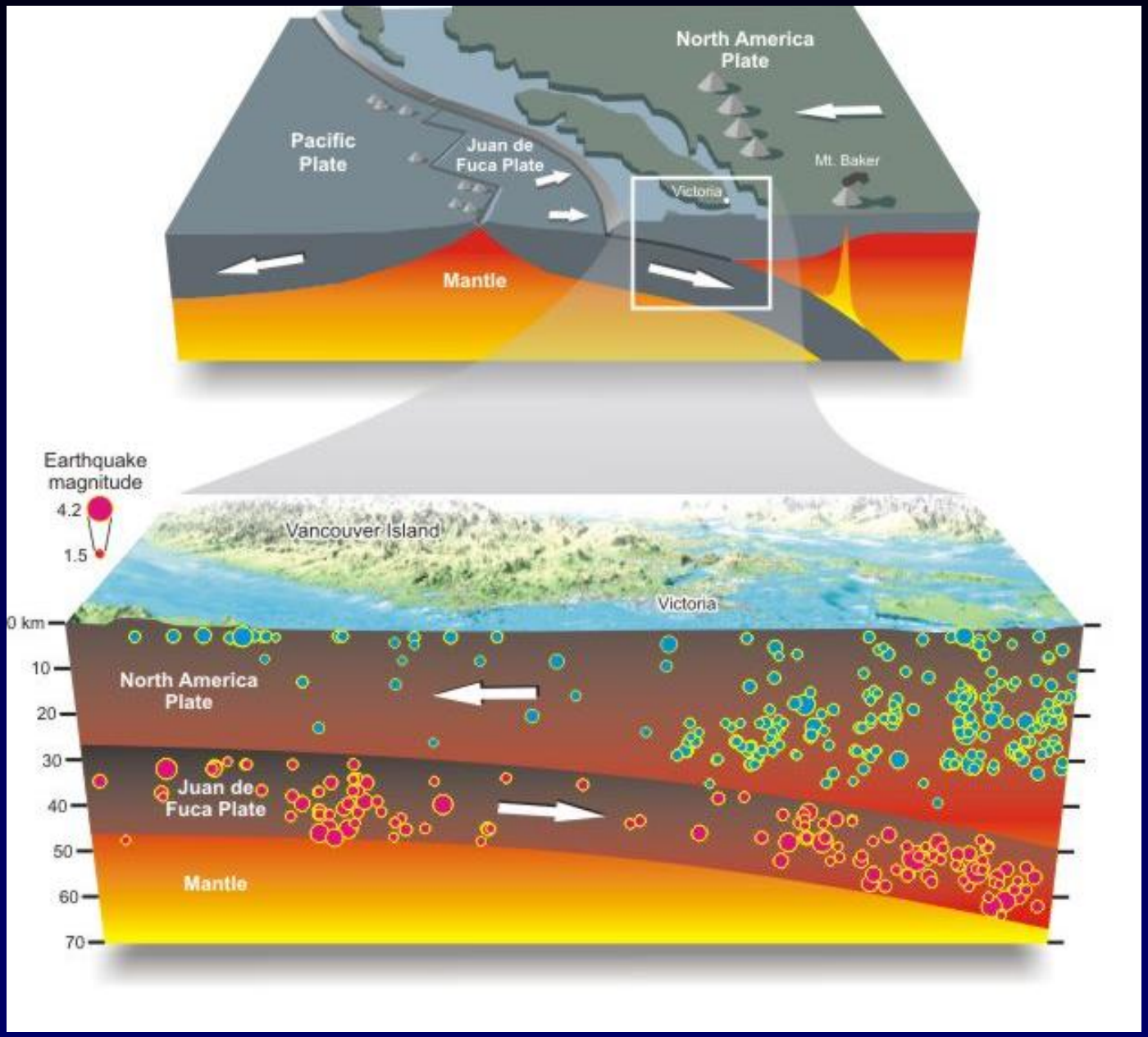
VII	General alarm. Difficult to stand. Damage to buildings.
VI	Felt by everyone. Difficult to walk. Objects fall.
V	Felt outdoors, Buildings sway.
IV	Felt by most people indoors.

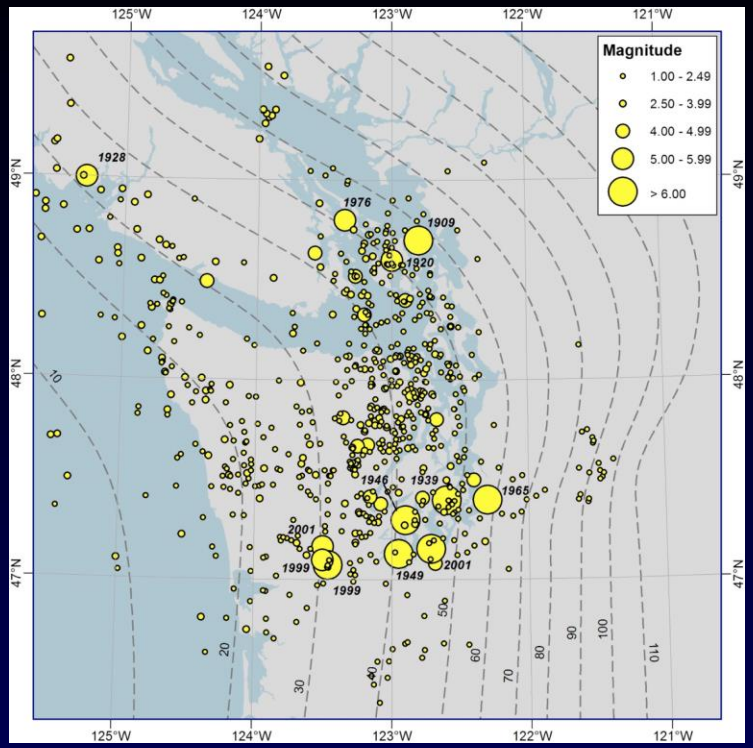




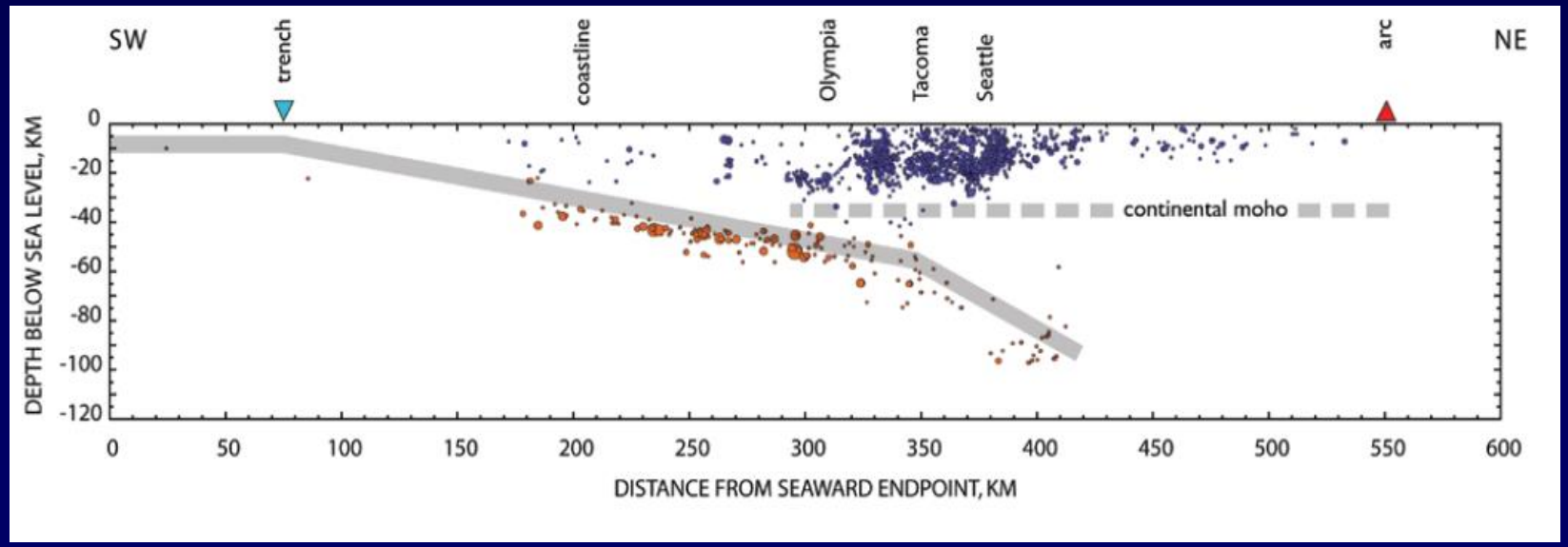


Three types of earthquakes

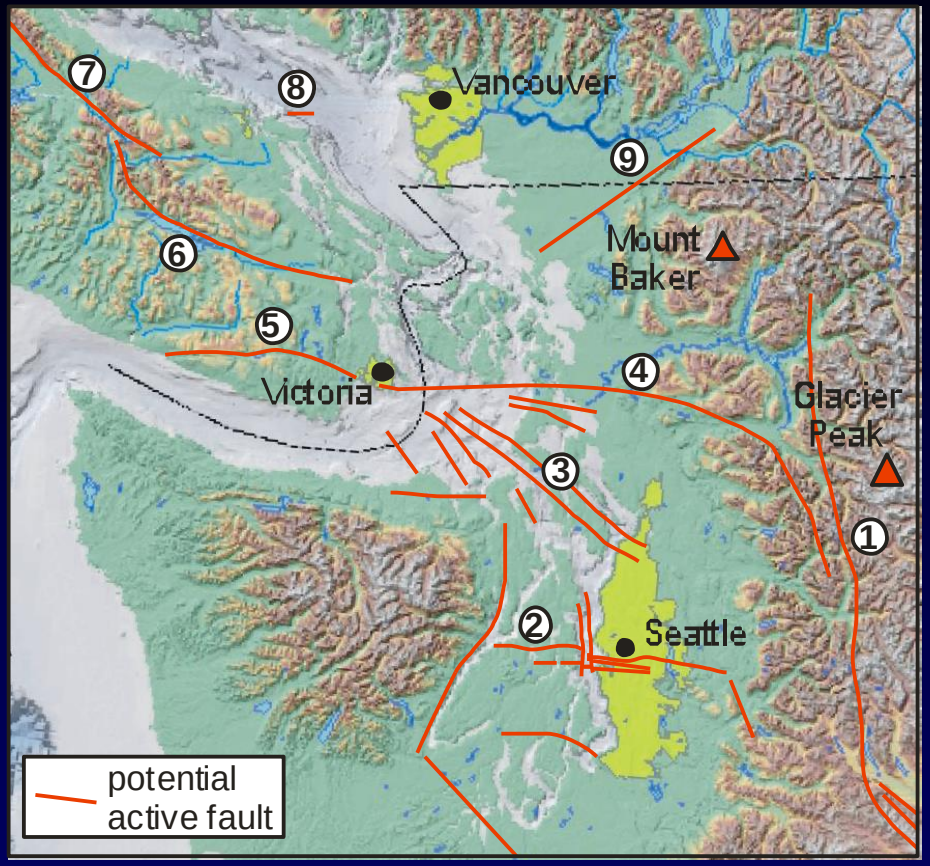




Slab earthquakes

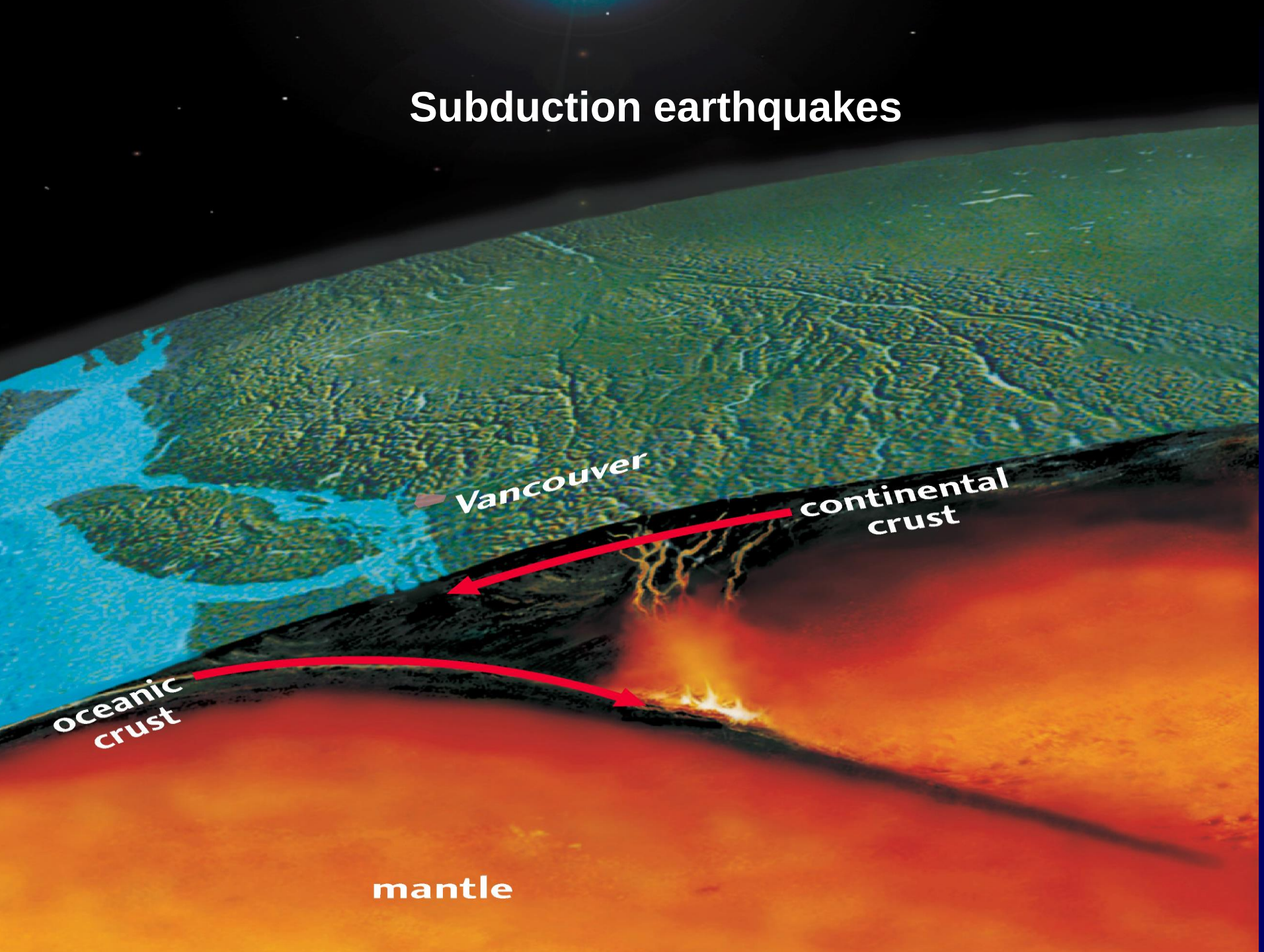


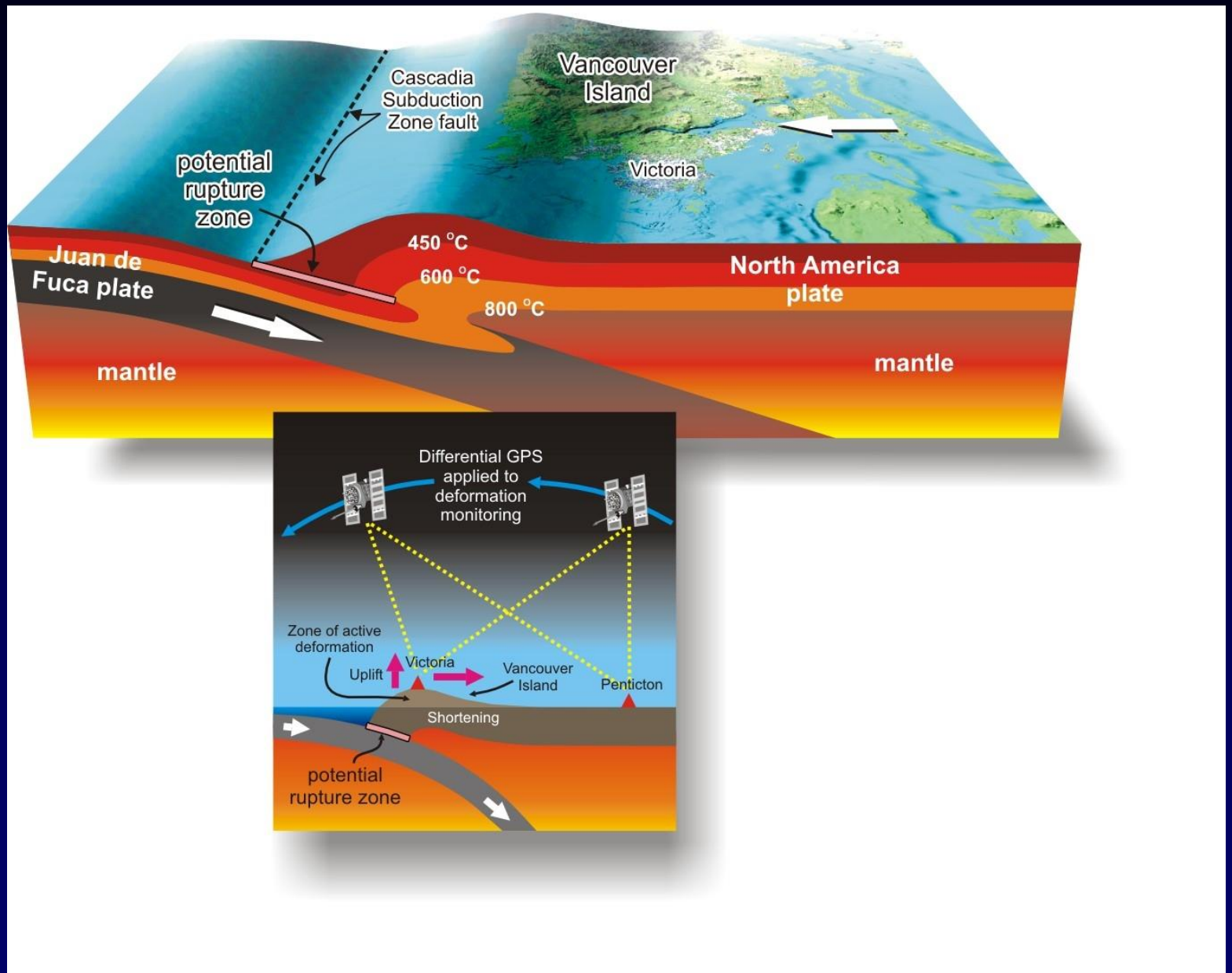
Crustal earthquakes



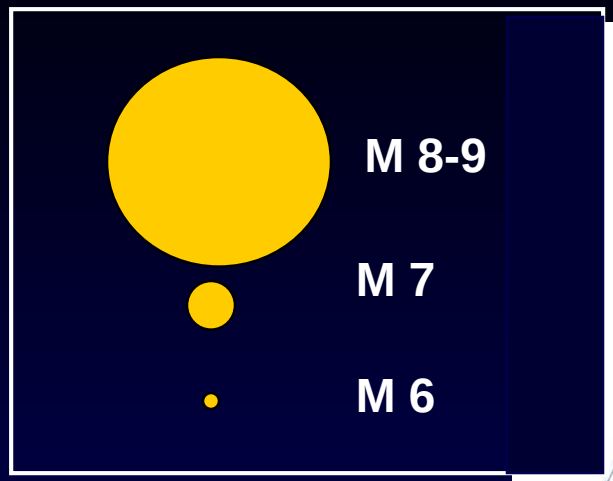
1 Straight Creek fault
2 Seattle fault
3 southern Whidbey Island fault
4 Devil Mountain fault
5 Leech River fault
6 Cowichan Lake fault
7 Beaufort Range fault
8 Strait of Georgia fault
9 Vedder and Sumas Mountain fault

Subduction earthquakes

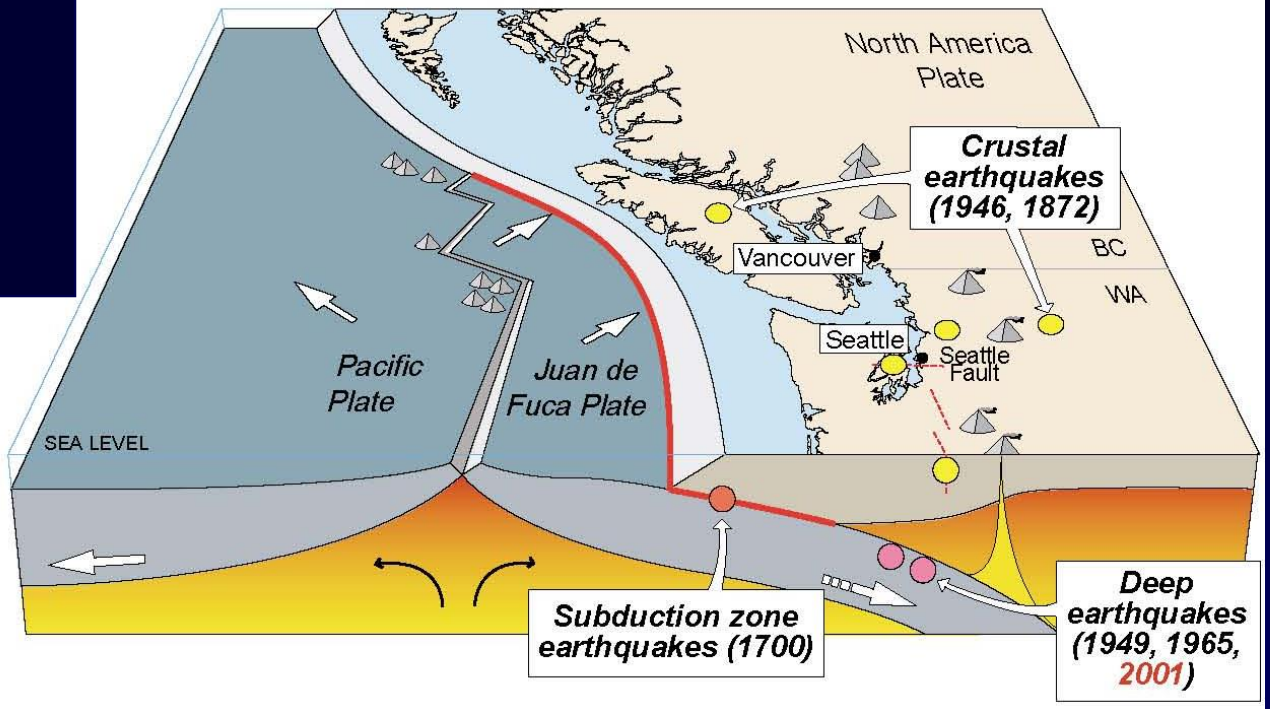



Cascadia
Subduction
Zone fault
Vancouver
Island
Victoria
potential
rupture
zone
450 °C
600 °C
800 °C
Juan de
Fuca plate
North America
plate
mantle
mantle
Differential GPS
applied to
deformation
monitoring
Zone of active
deformation
Uplift
Victoria
Vancouver
Island
Penticton
Shortening
potential
rupture zone

How likely are we to have a damaging earthquake?



Cascadia Earthquake Sources



Source	Affected area	Max. Size	Recurrence
Subduction zone	BC, WA, OR, CA	M 9	500-600 yrs
Deep Juan de Fuca plate	BC, WA, OR	M 7+	30-50 yrs
Crustal faults	BC, WA, OR, CA	M 7+	Tens of yrs

Damaging earthquake effects

- Fire
- Ground rupture
- Ground shaking
- Ground motion amplification
- Tsunami
- Liquefaction
- Landslides
- Aftershocks

San Francisco 1906

Fire

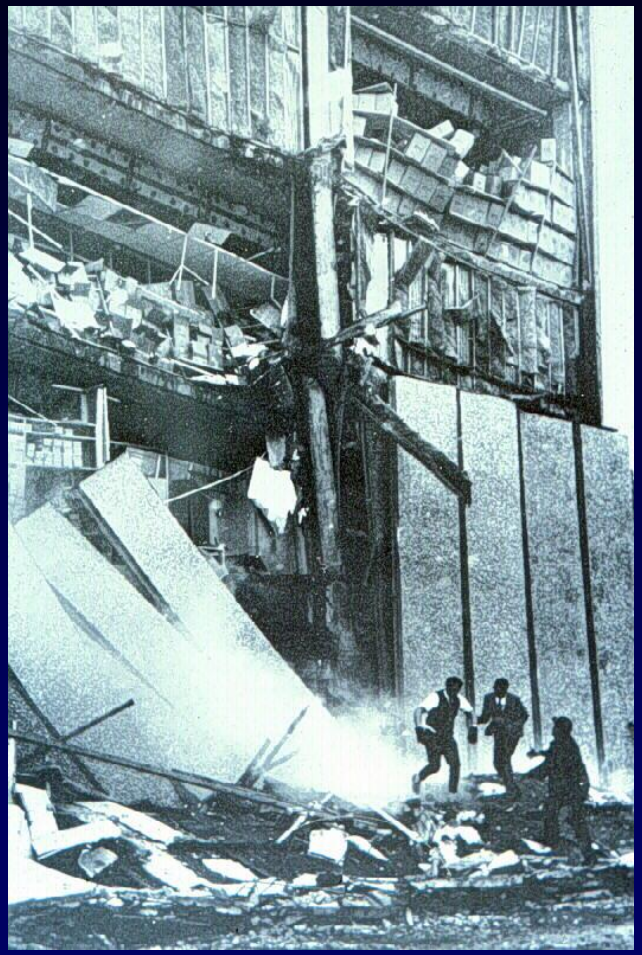
Kobe 1995

Ground rupture

Southern California

Ground shaking

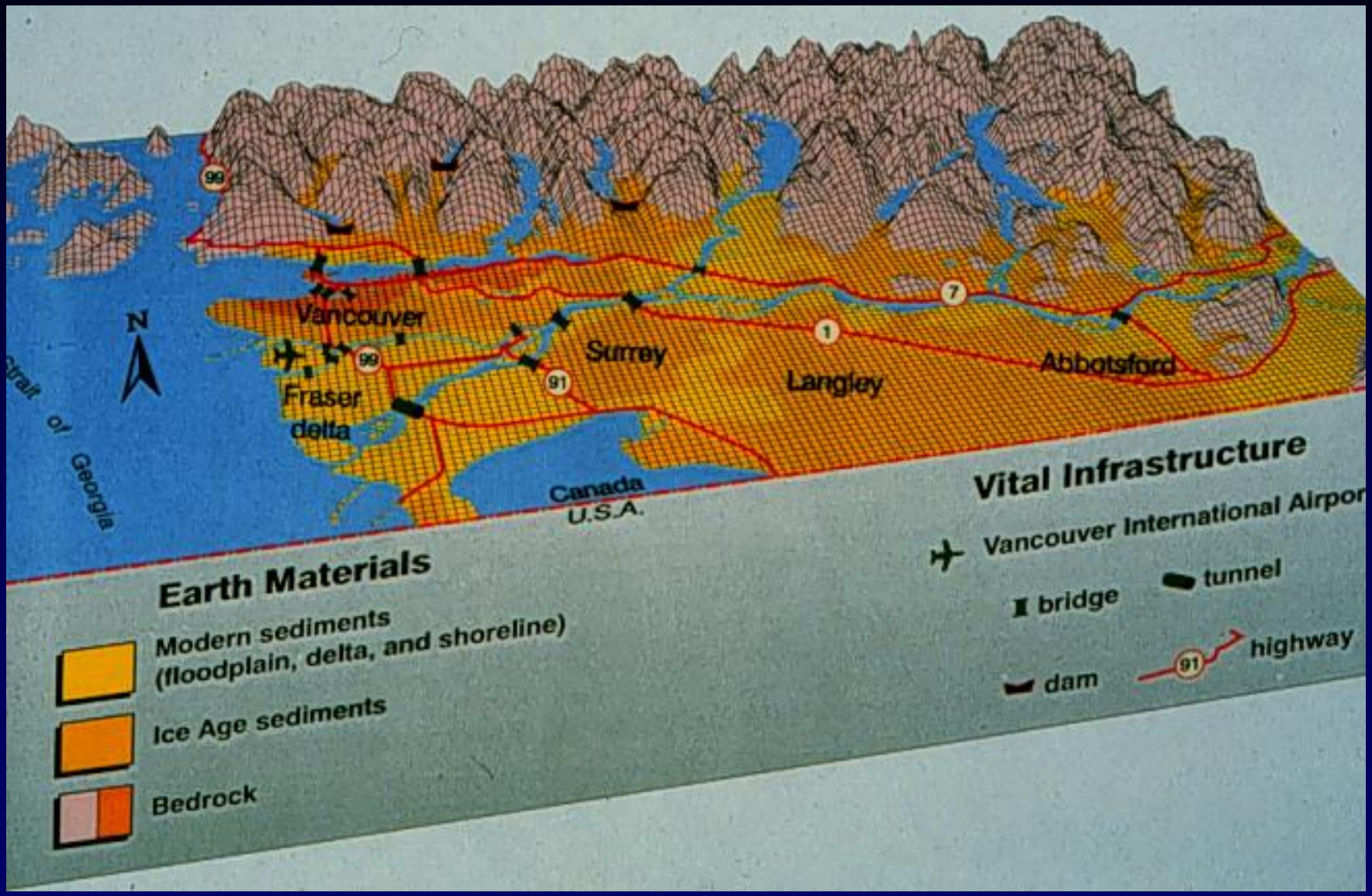
Kobe 1995



Anchorage 1964

Shaking intensity depends on many things and can differ considerably over short distances….

For example, geology and topography are important



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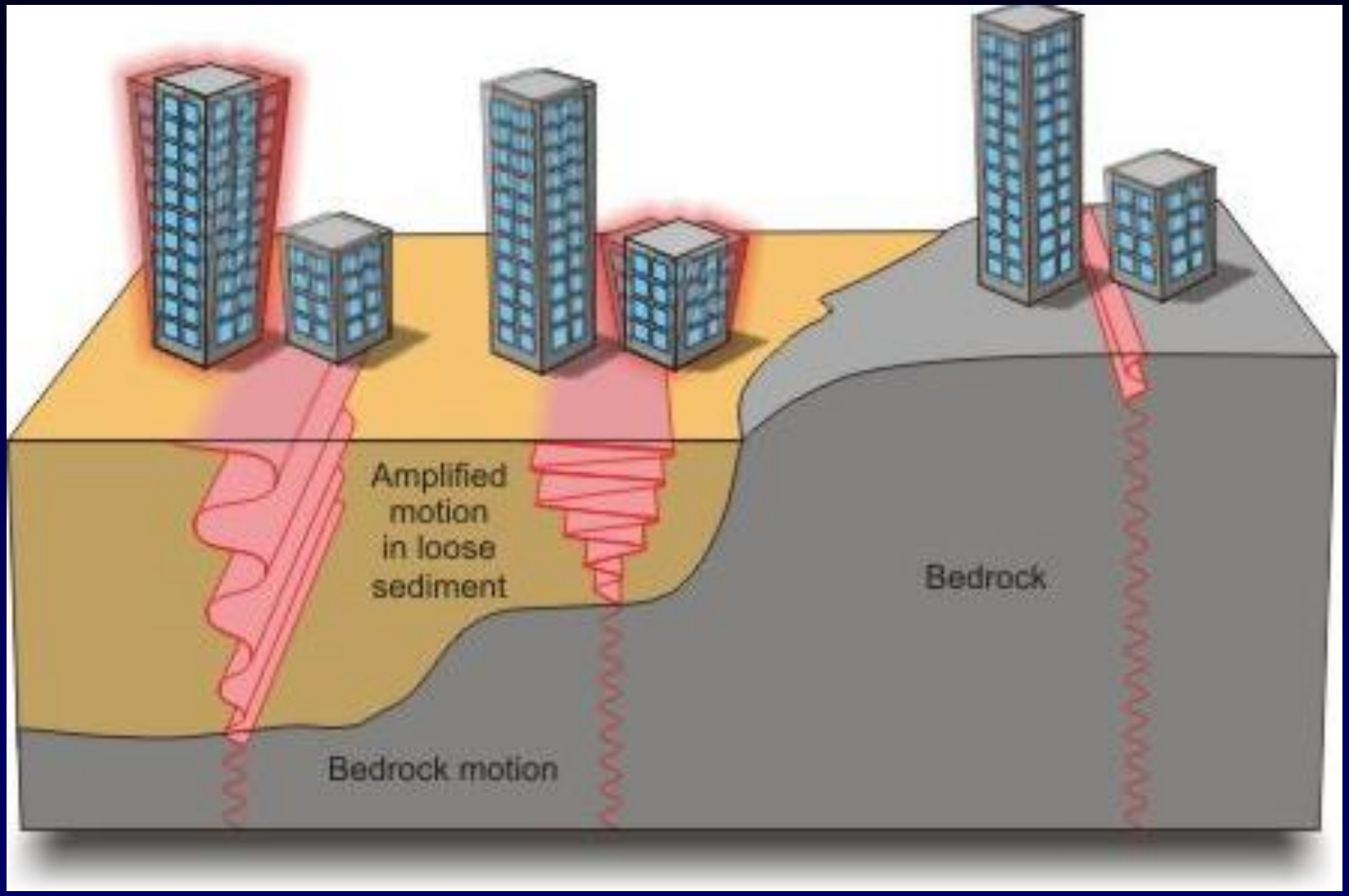
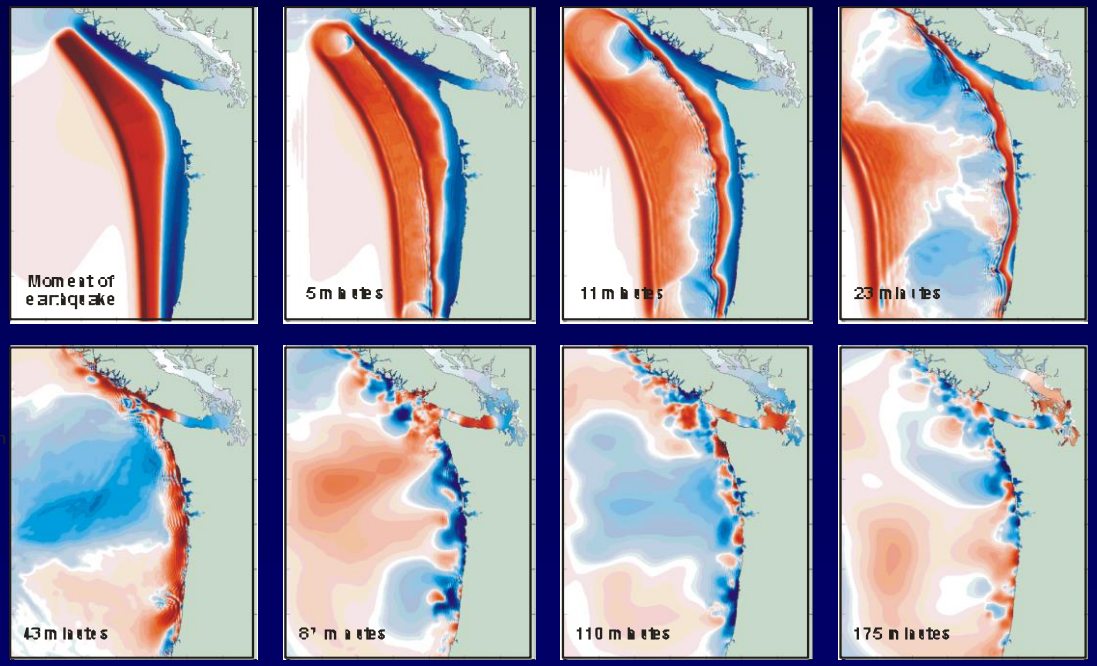
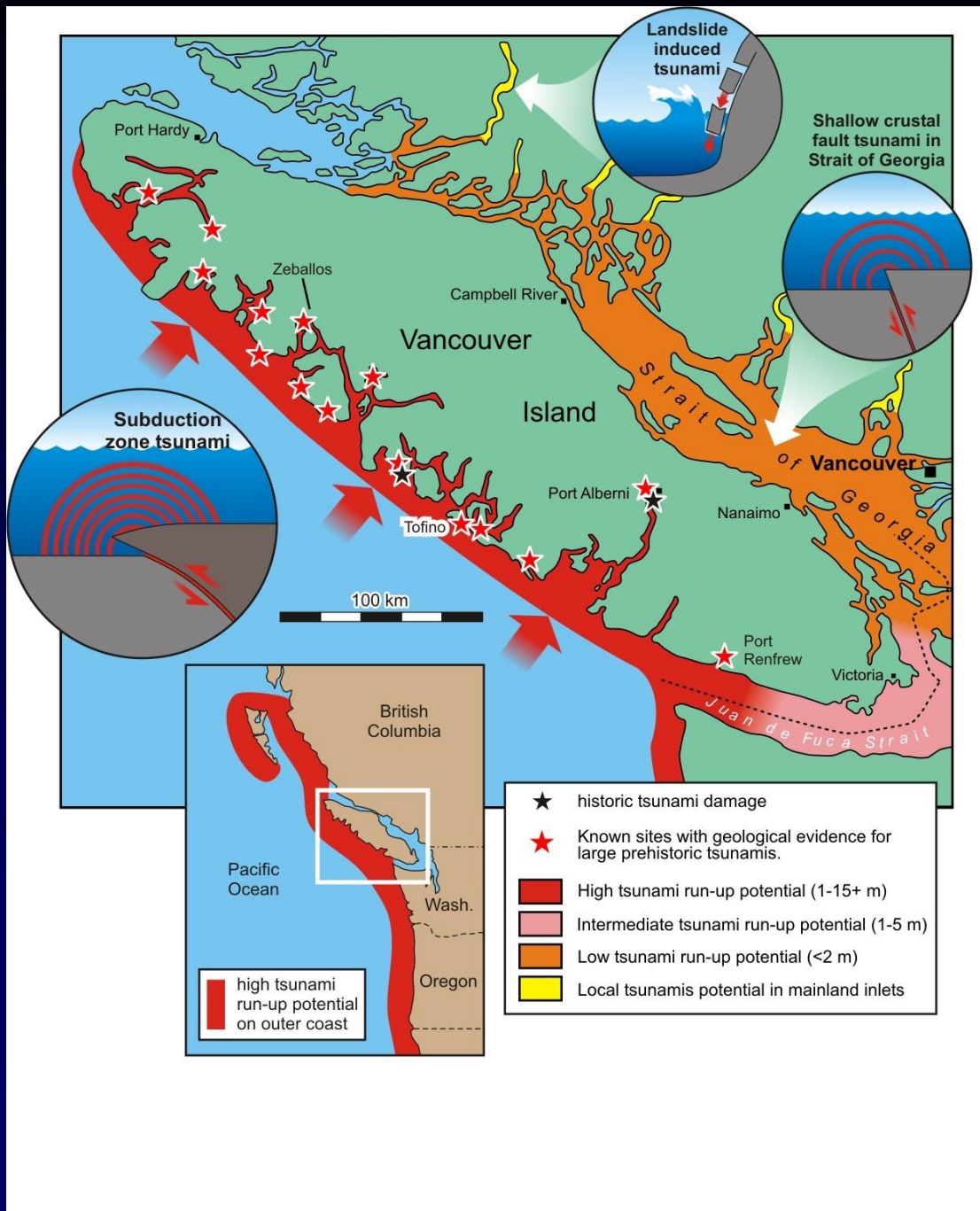
Ground motion amplification

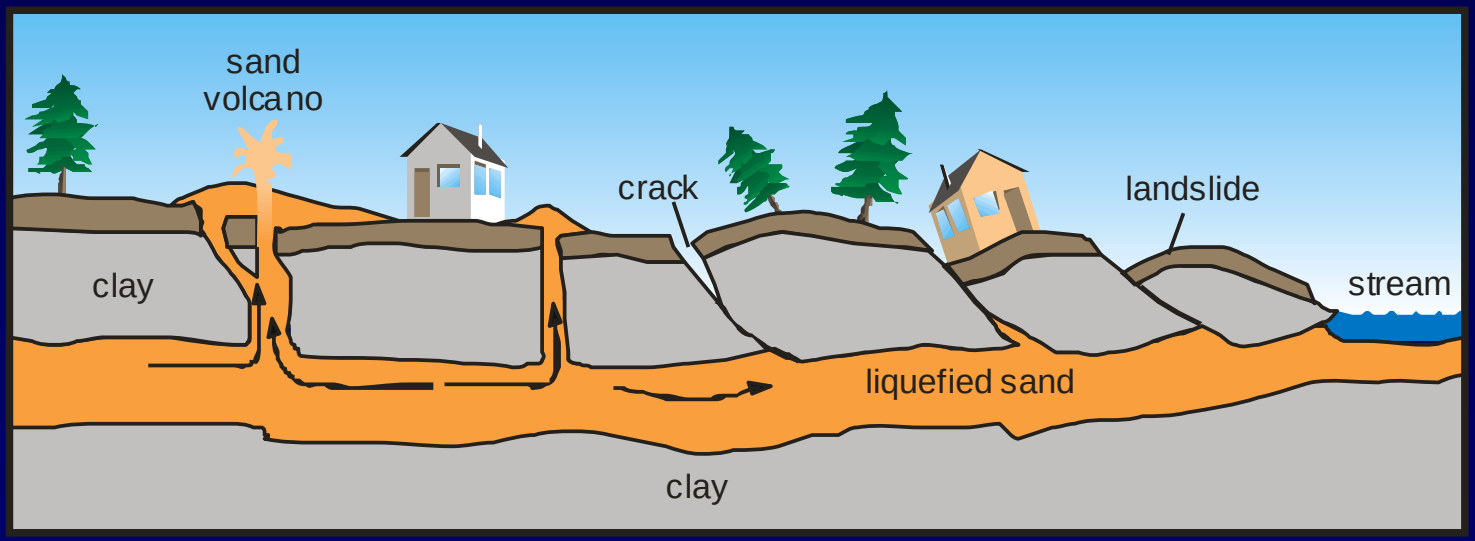


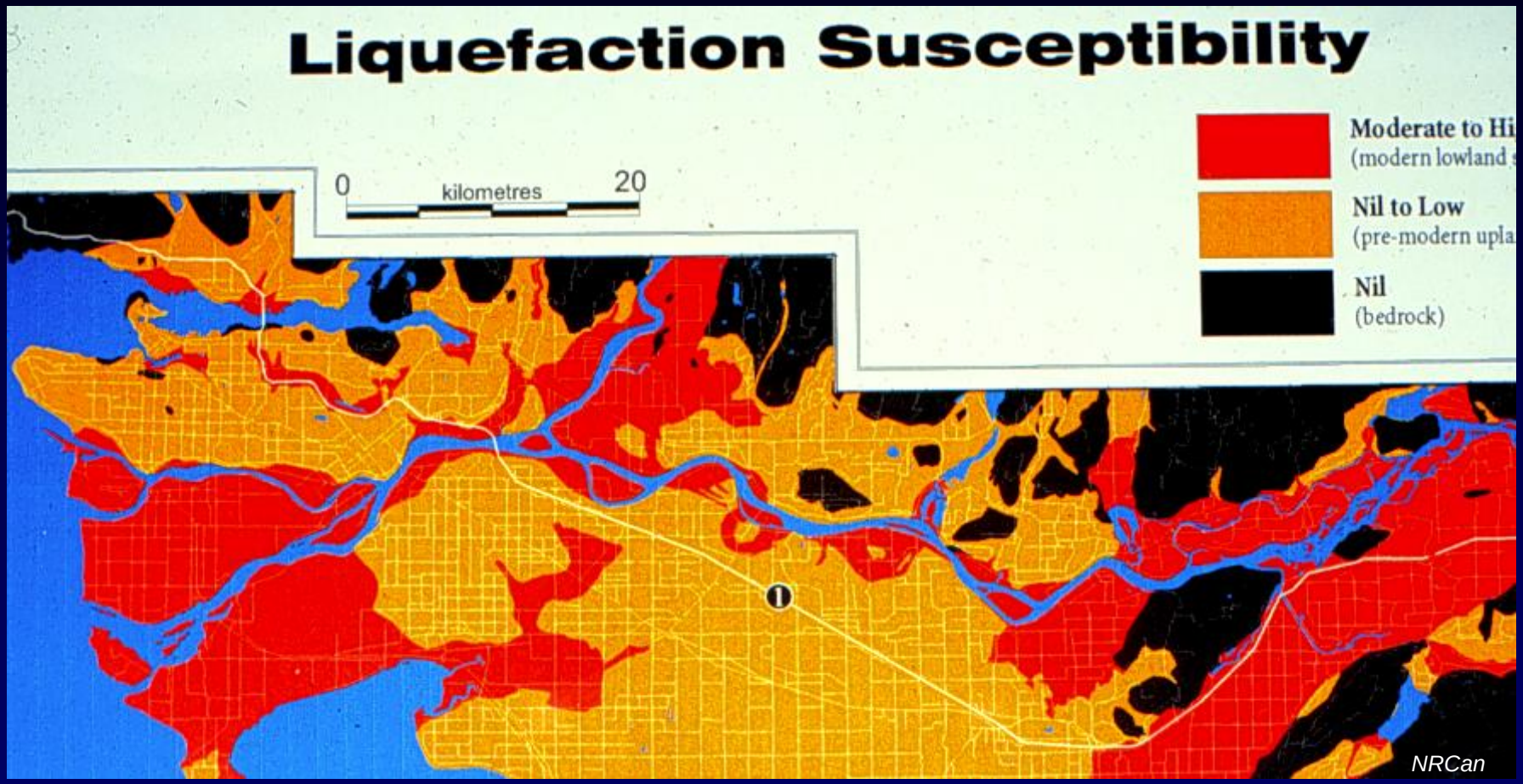
Tsunami


Moment of earthquake
5 minutes
11 minutes
23 minutes
43 minutes
87 minutes
110 minutes
175 minutes


Landslide induced tsunami
Shallow crustal fault tsunami in Strait of Georgia
Subduction zone tsunami
Port Hardy
Zeballos
Campbell River
Vancouver
Island
Strait of Georgia
Vancouver
Port Alberni
Nanaimo
Tofino
100 km
Port Renfrew
Victoria
Juan de Fuca Strait
British Columbia
Pacific Ocean
Wash.
Oregon
high tsunami run-up potential on outer coast
historic tsunami damage
Known sites with geological evidence for large prehistoric tsunamis.
High tsunami run-up potential (1-15+ m)
Intermediate tsunami run-up potential (1-5 m)
Low tsunami run-up potential (<2 m)
Local tsunamis potential in mainland inlets

Liquefaction



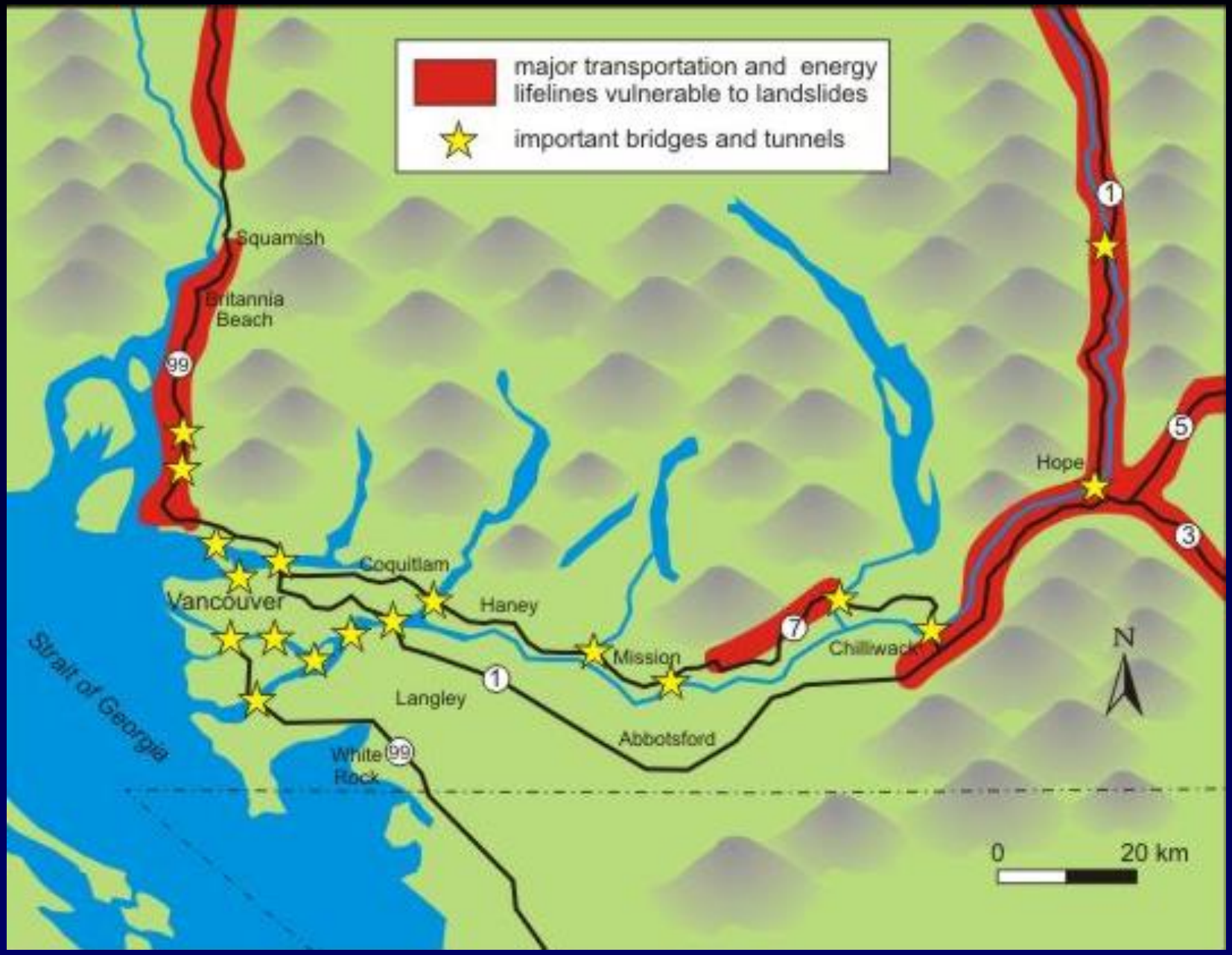

Liquefaction Susceptibility
0
kilometres
20
Moderate to Hi
(modern lowland
Nil to Low
(pre-modern upla
Nil
(bedrock)
NRCan

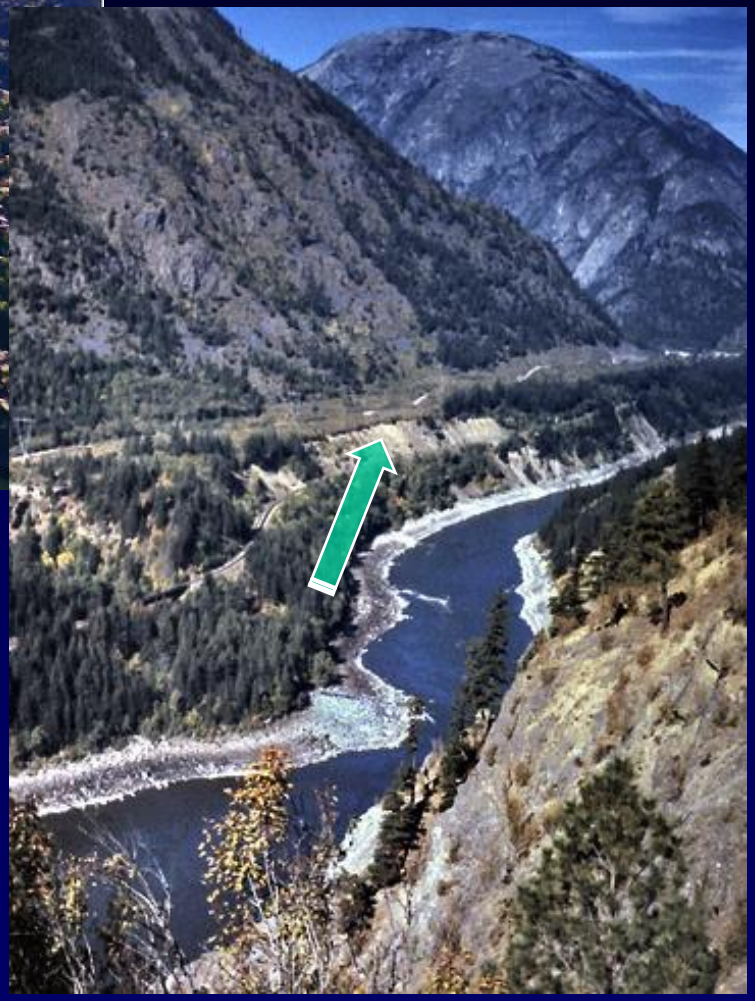
NRCan

Landslides

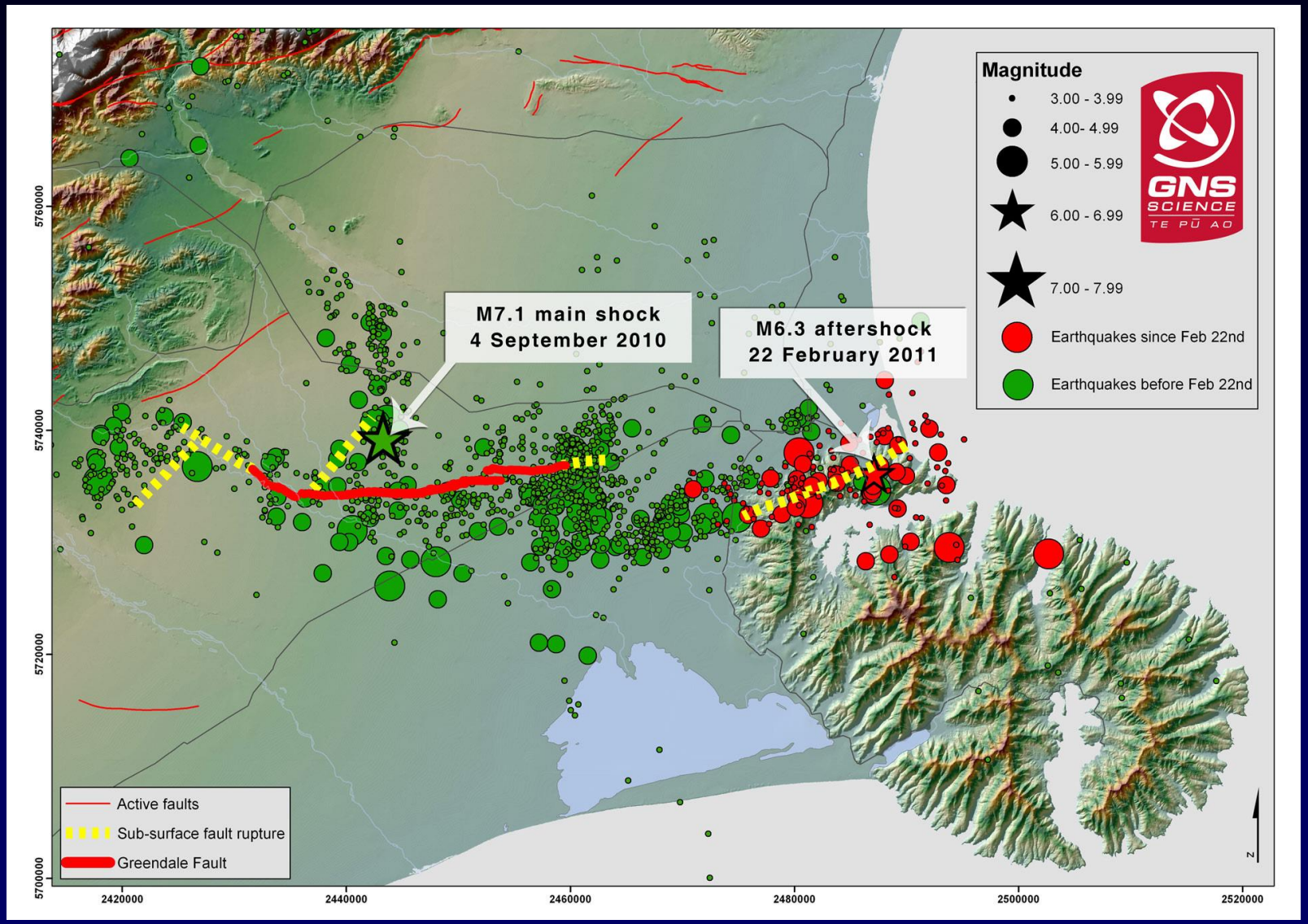
CBC

Duncan Wyllie


major transportation and energy lifelines vulnerable to landslides
important bridges and tunnels
Squamish
Britannia Beach
99
Vancouver
Coquitlam
Haney
Mission
Langley
Abbotsford
White Rock
Chilliwack
Hope
1
5
3
7
Strait of Georgia
N
0
20 km



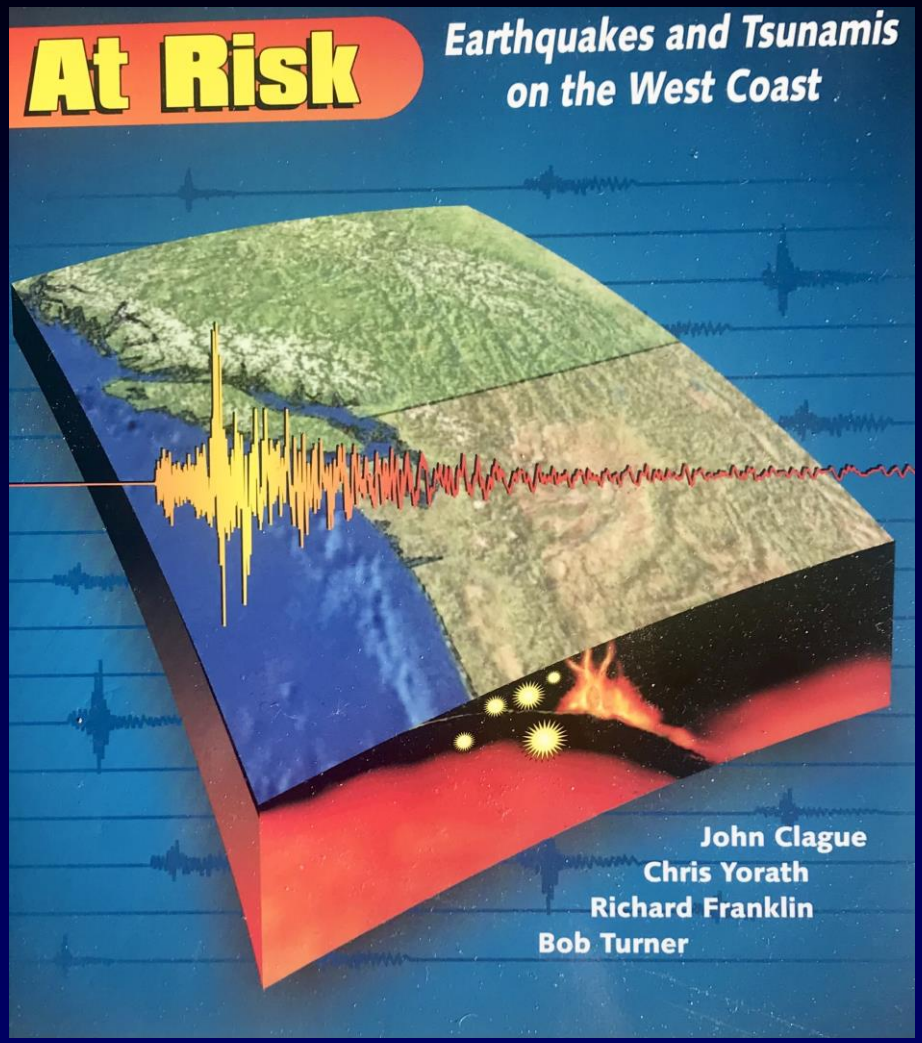
Aftershocks



Our vulnerabilities

- Damage to bridges and tunnels
- Landslides on Sea-to-Sky Highway and Fraser Canyon
- Port facilities - Liquefaction along shorelines
- Debris on roads
- Rupture of buried utility lines (water and gas lines)
- Damage to critical infrastructure (e.g. port facilities, fire stations, hospitals, cell towers)
- Where do we house people who have been displaced from damaged homes

Want more information?



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