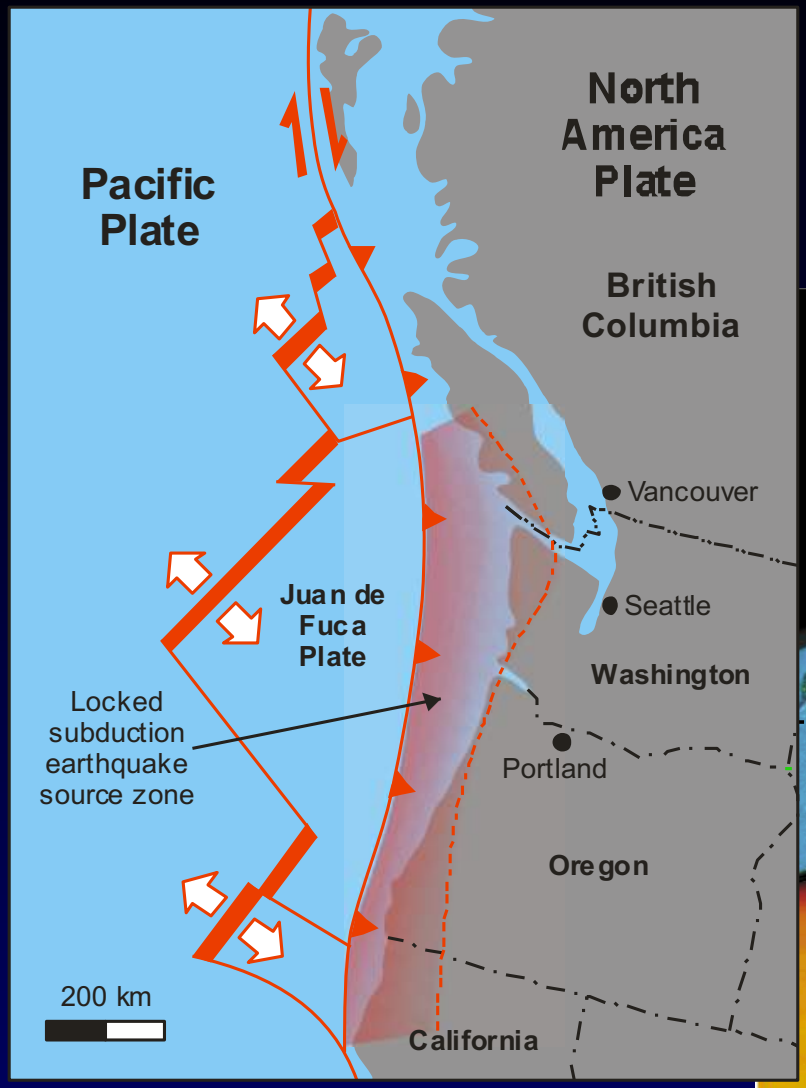
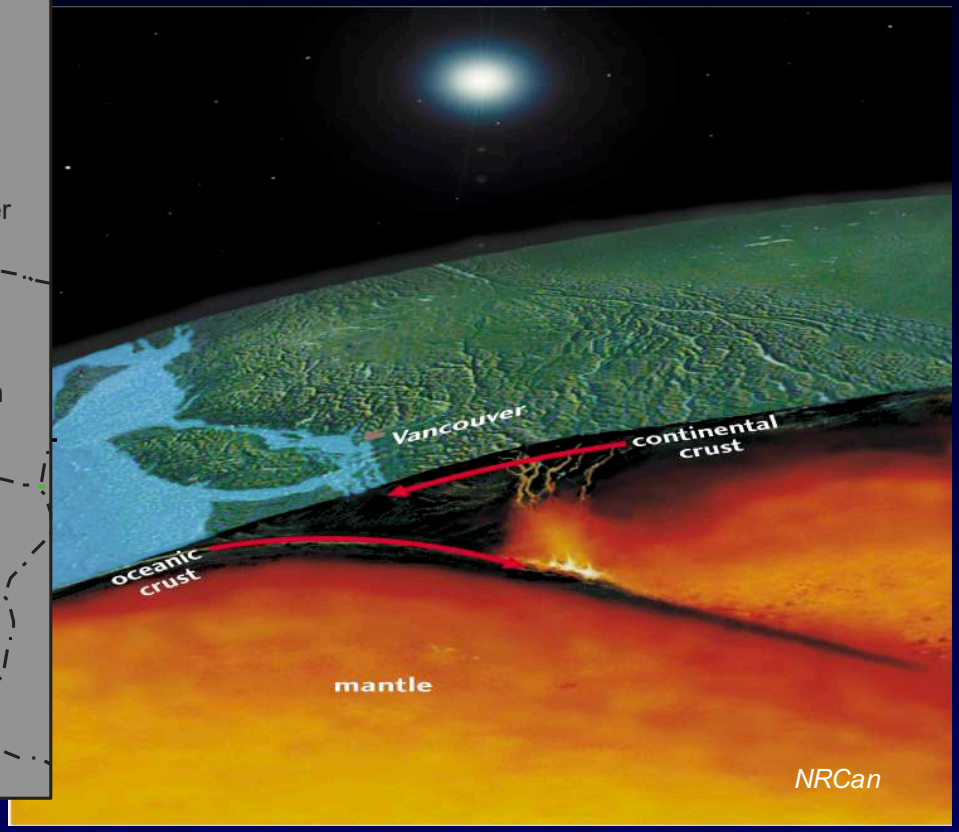
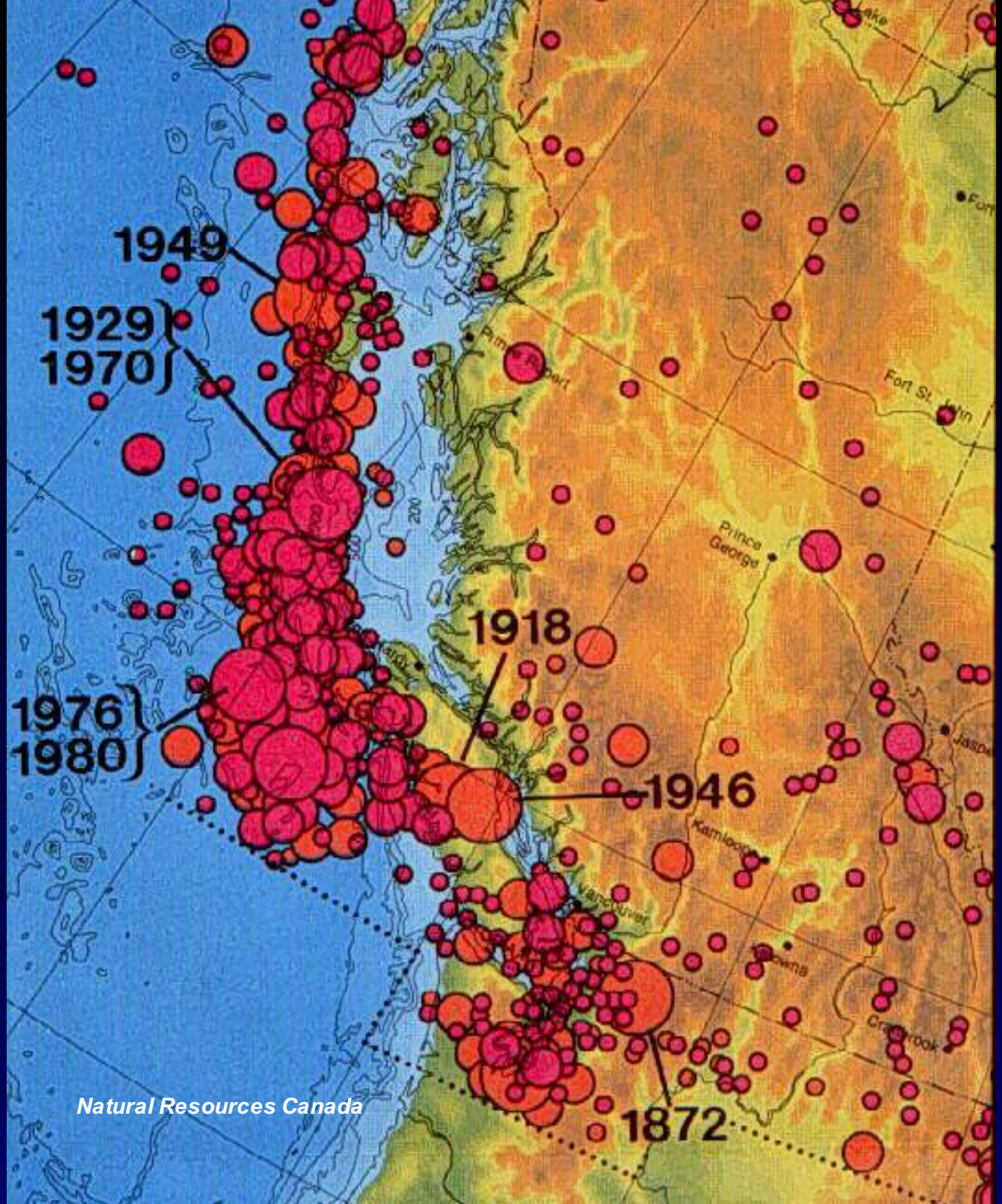

Earthquake rocks border area between Iraq, Iran
Updated 11:58 AM ET, Mon November 13, 2017
Black Sea
Caspian Sea
24 mm/yr
28 mm/yr
38 mm/yr
Arabia Plate
Persian Gulf
34 mm/yr
Gulf of Oman
11 mm/yr
M8.1 1945
Indian Ocean
Red Sea
15 mm/yr

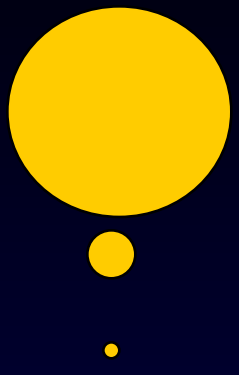
Why do we have earthquakes? …






1949
1929
1970
1918
1976
1980
1946
1872
Prince George
Fort St. John
Natural Resources Canada

How likely are we to have a damaging earthquake?…

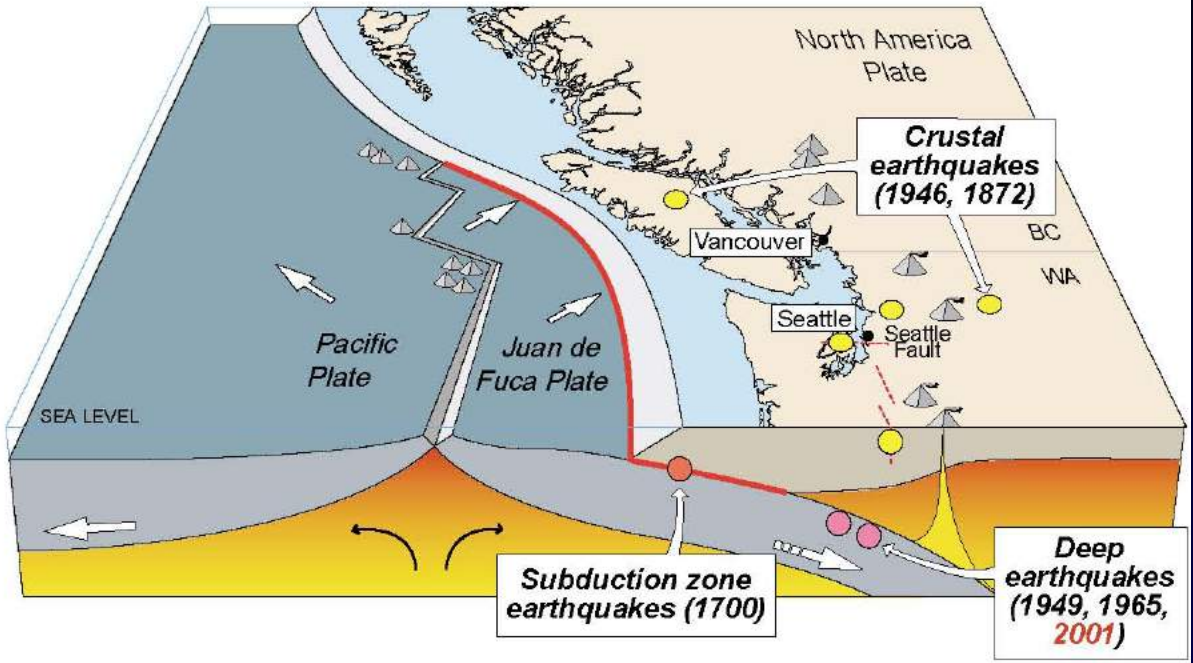


M 8-9

M 7

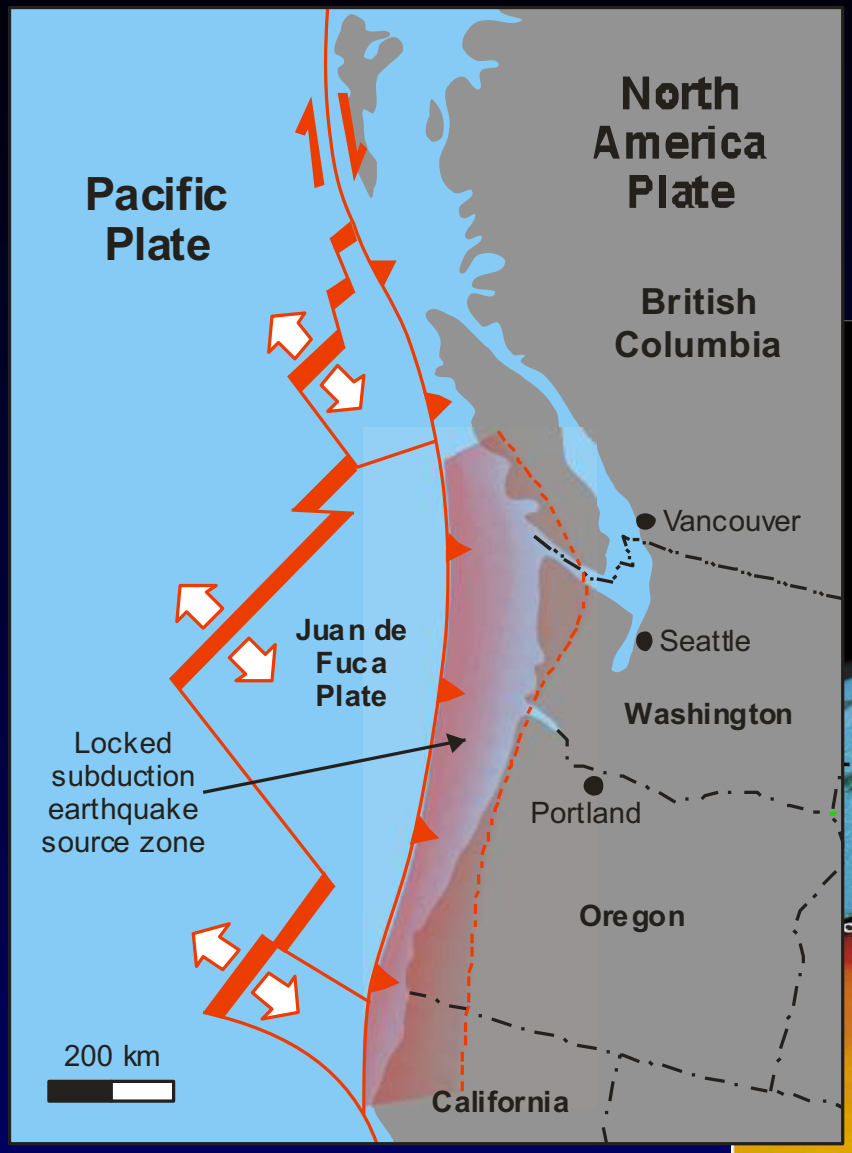
M 6

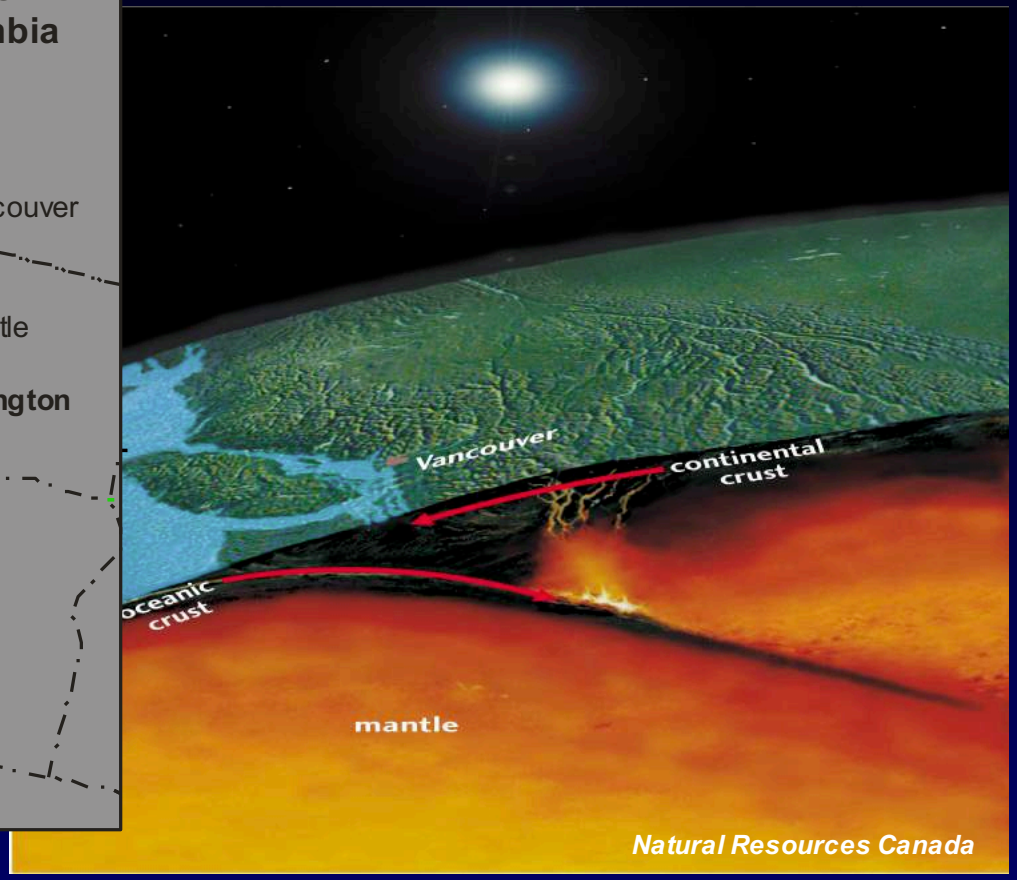
Cascadia Earthquake Sources

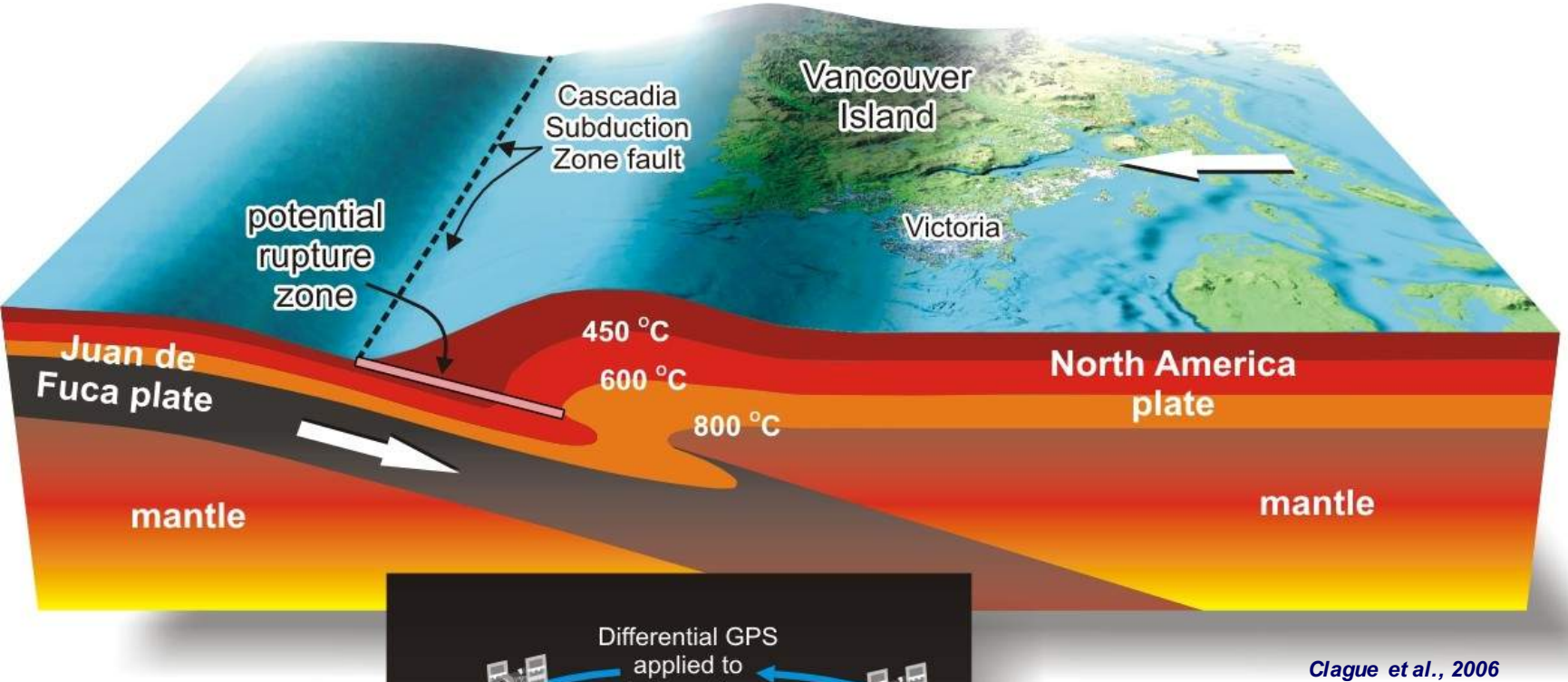


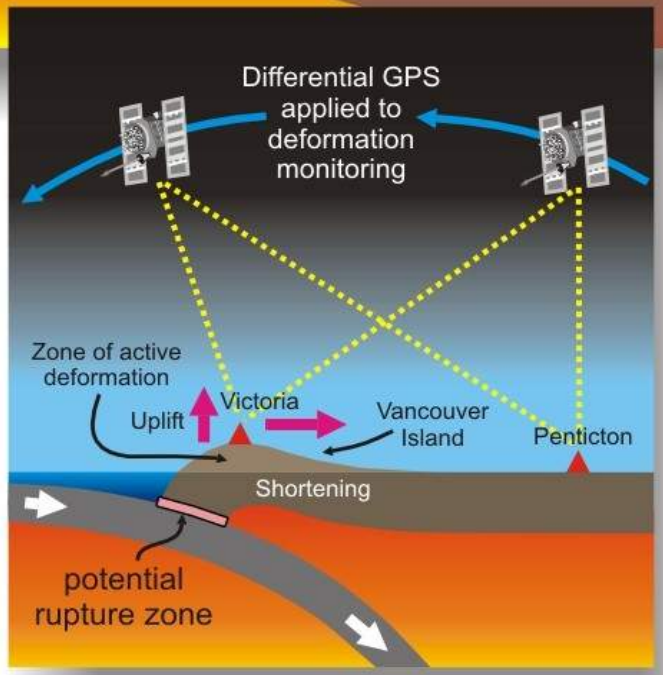
Source	Affected area	Max. Size	Recurrence
Subduction zone	BC, WA, OR, CA	M 9	500-600 yrs
Deep Juan de Fuca plate	BC, WA, OR	M 7+	30-50 yrs
Crustal faults	BC, WA, OR, CA	M 7+	Tens of yrs

Subduction earthquakes



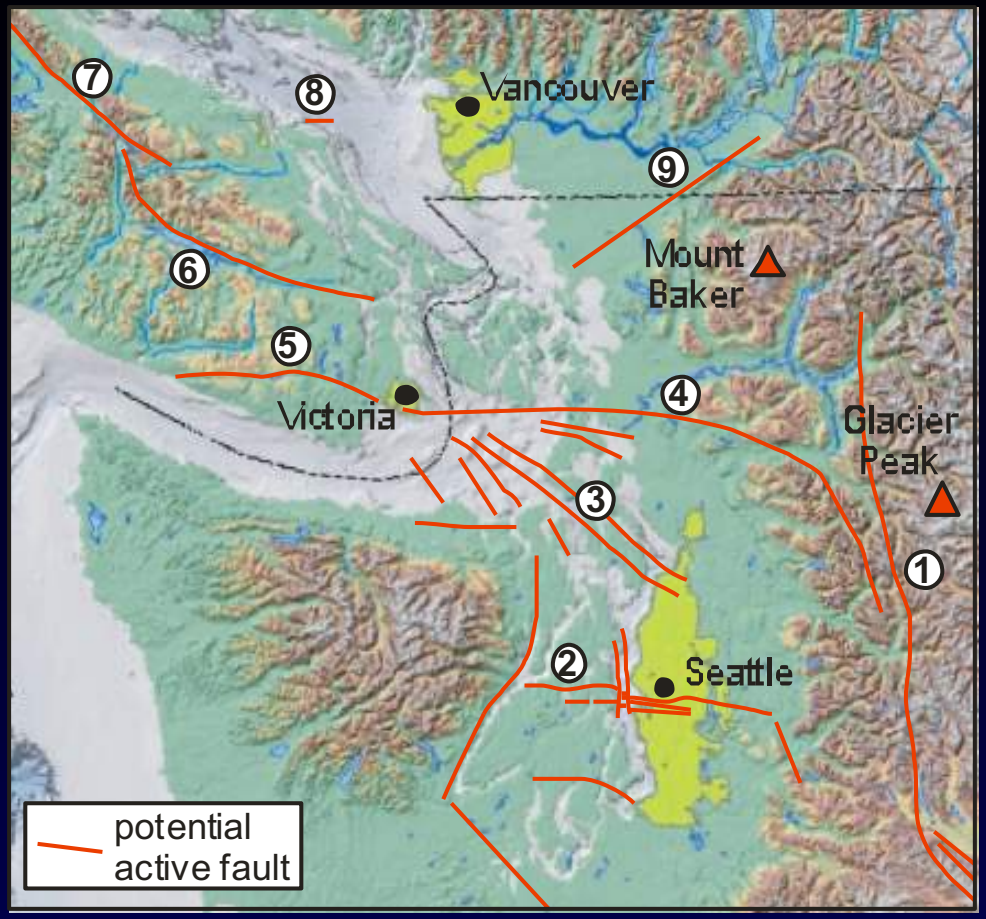






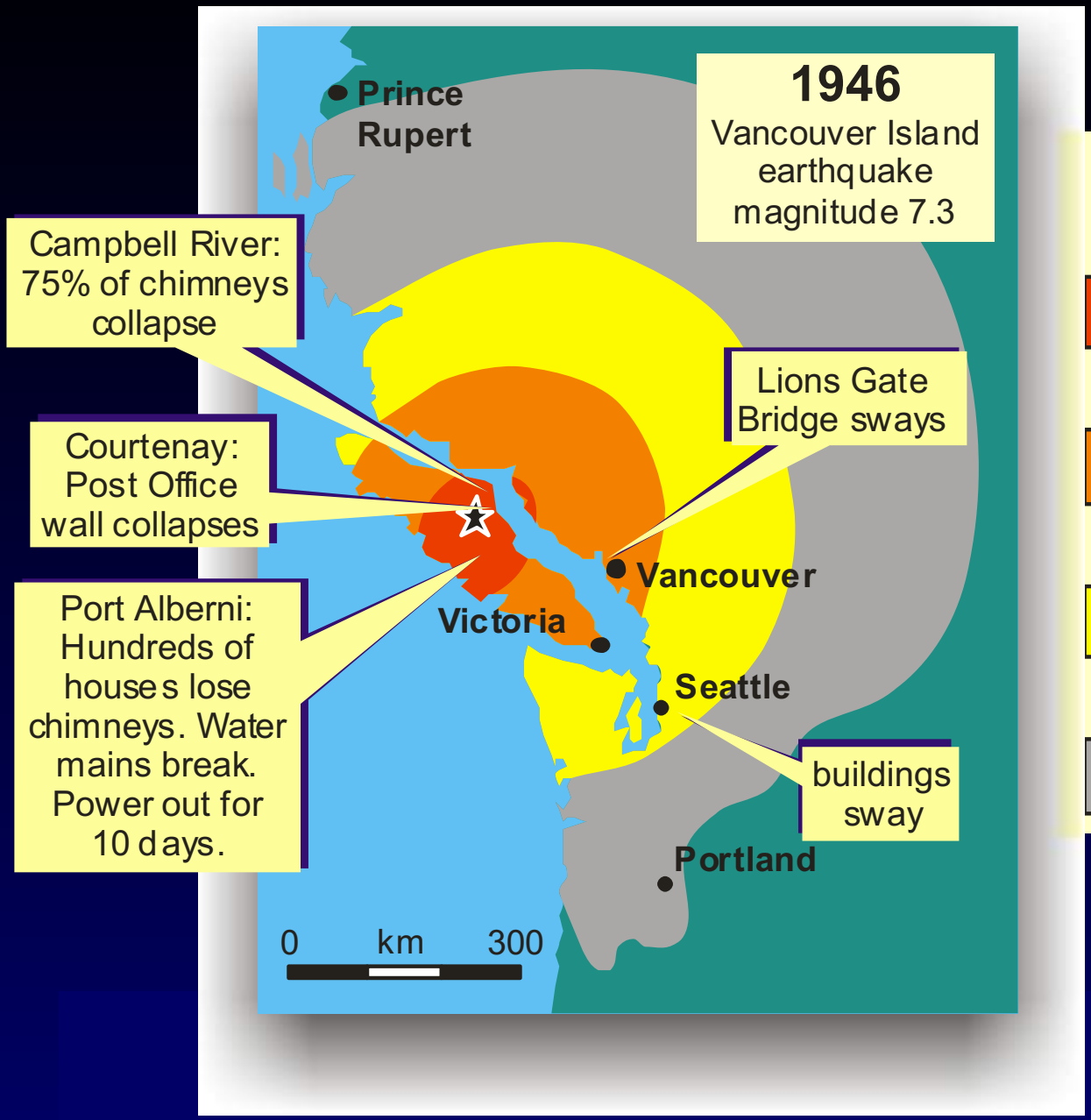
Clague et al., 2006

Crustal earthquakes

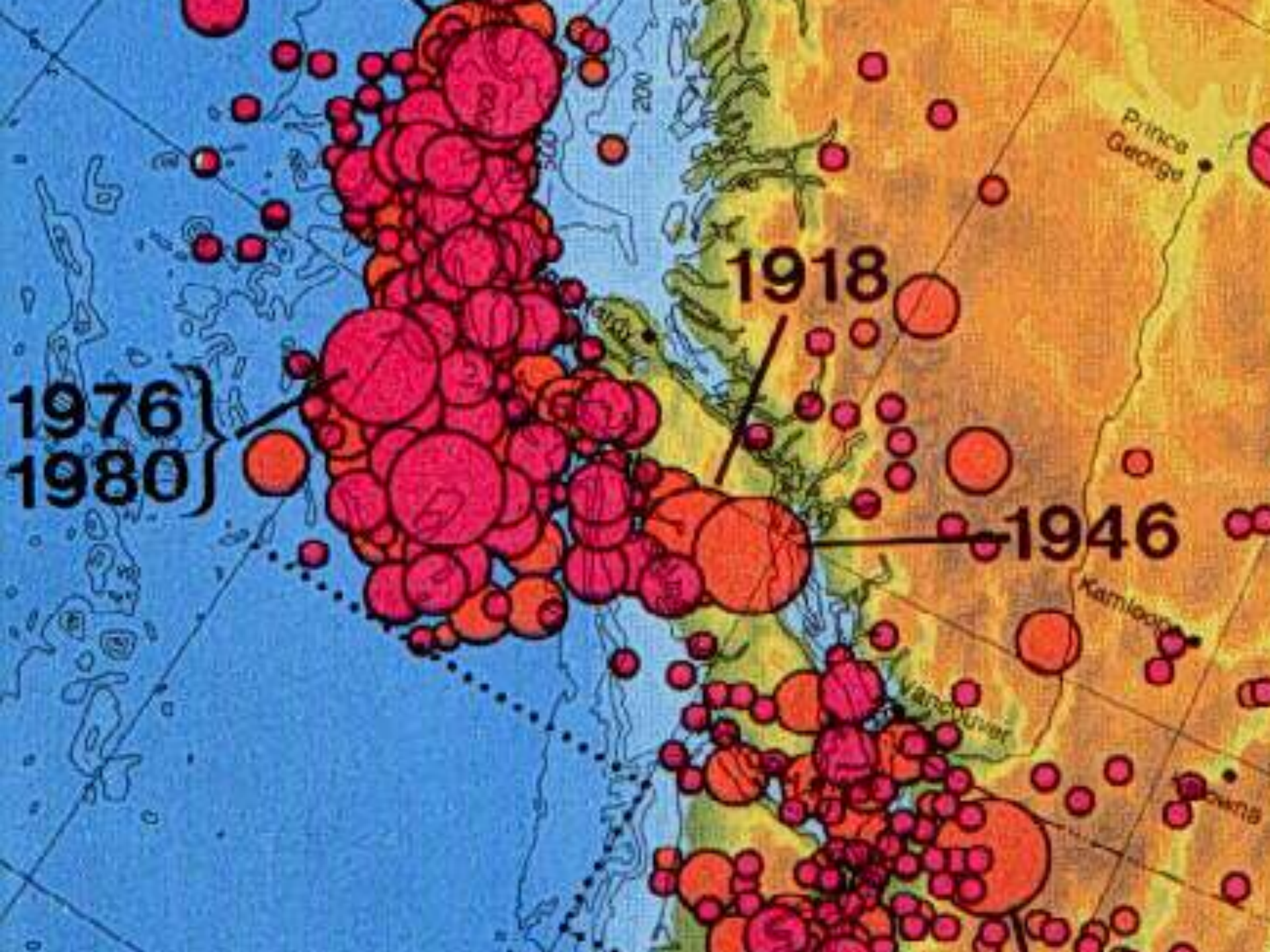


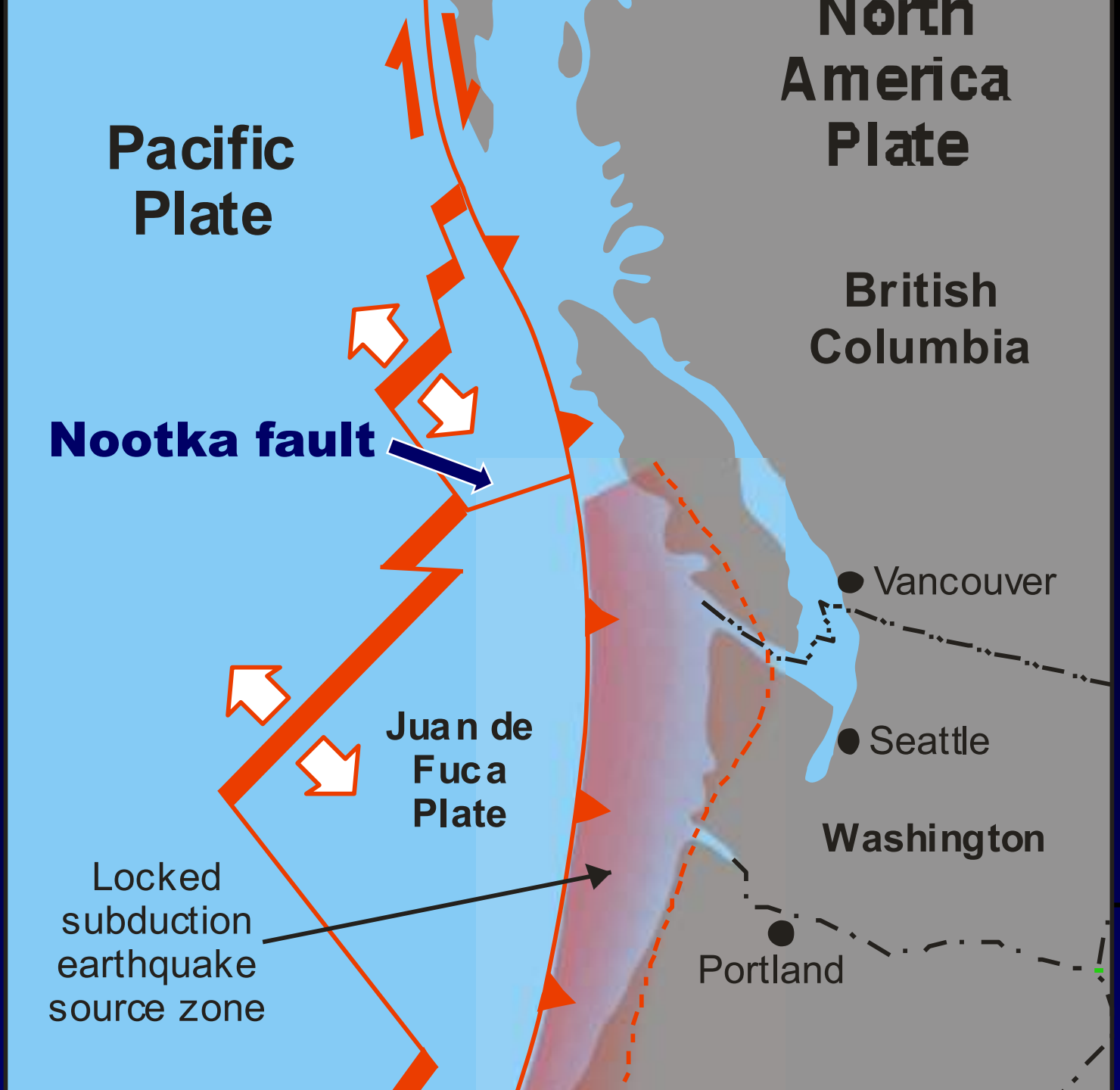
Clague et al., 2006

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



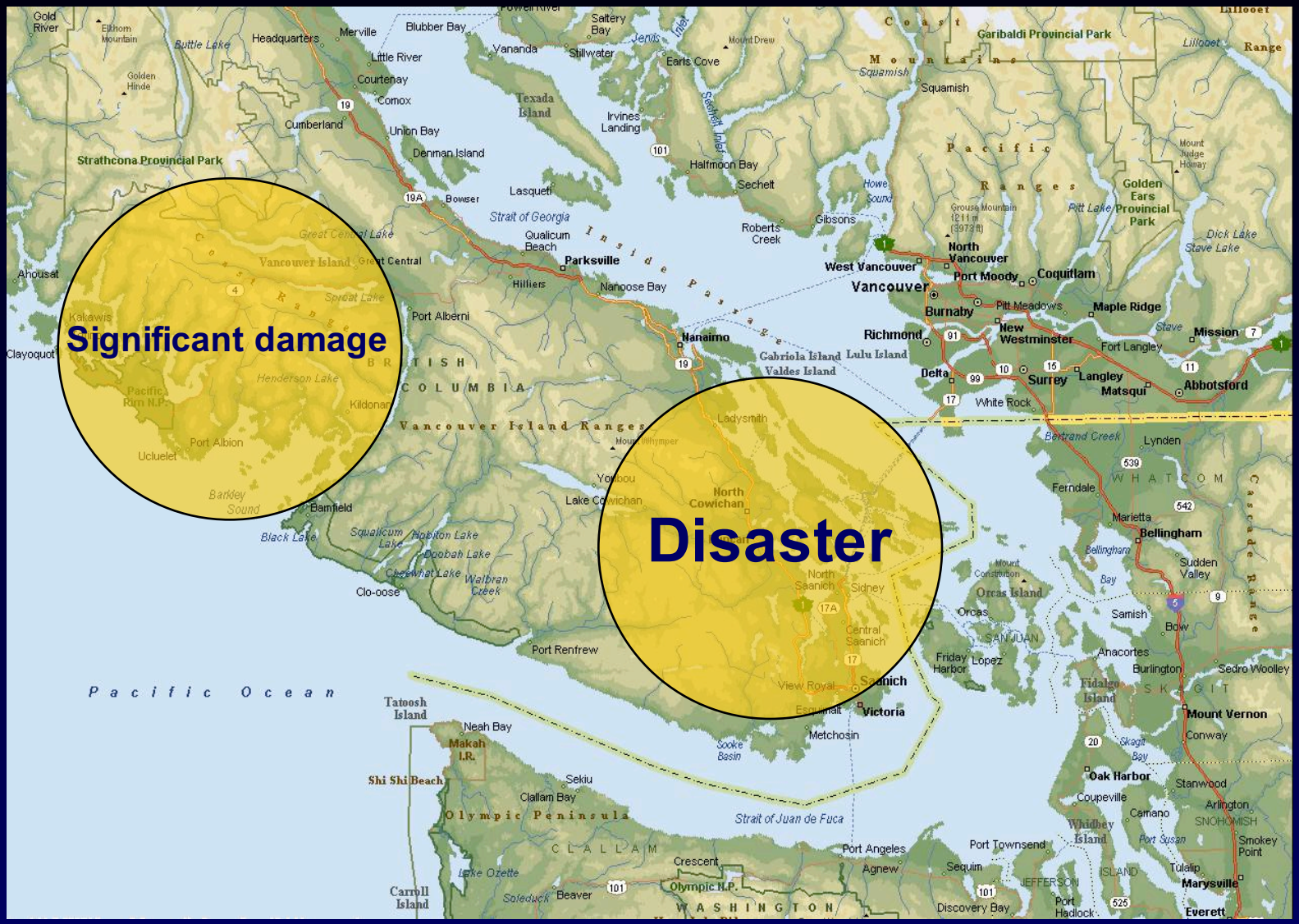
Clague and Turner, 2003


1976
1980
1918
1946
Prince George
Kamloops
Vancouver
200

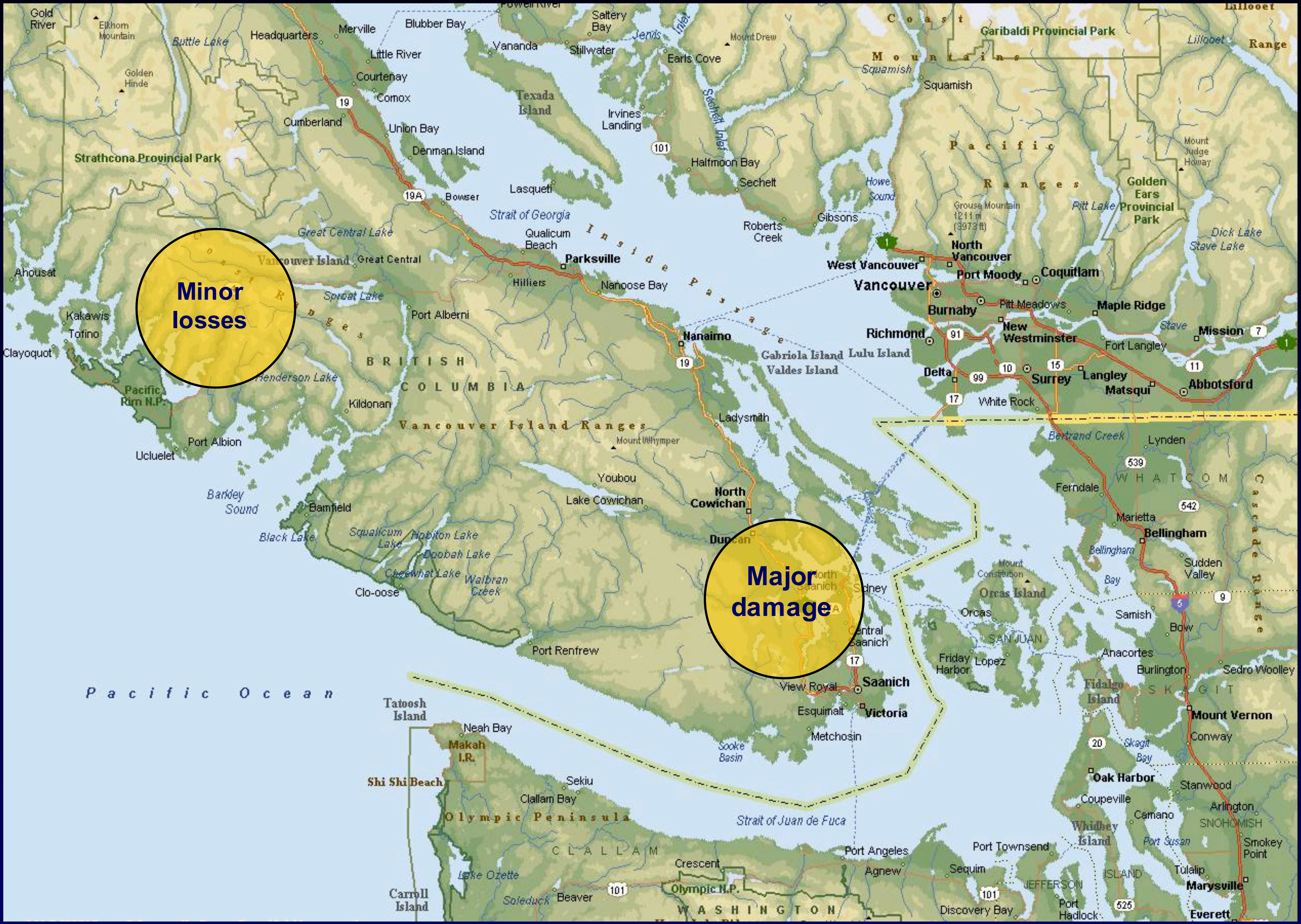

North America Plate
Pacific Plate
British Columbia
Nootka fault
Vancouver
Juan de Fuca Plate
Seattle
Washington
Locked subduction earthquake source zone
Portland

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

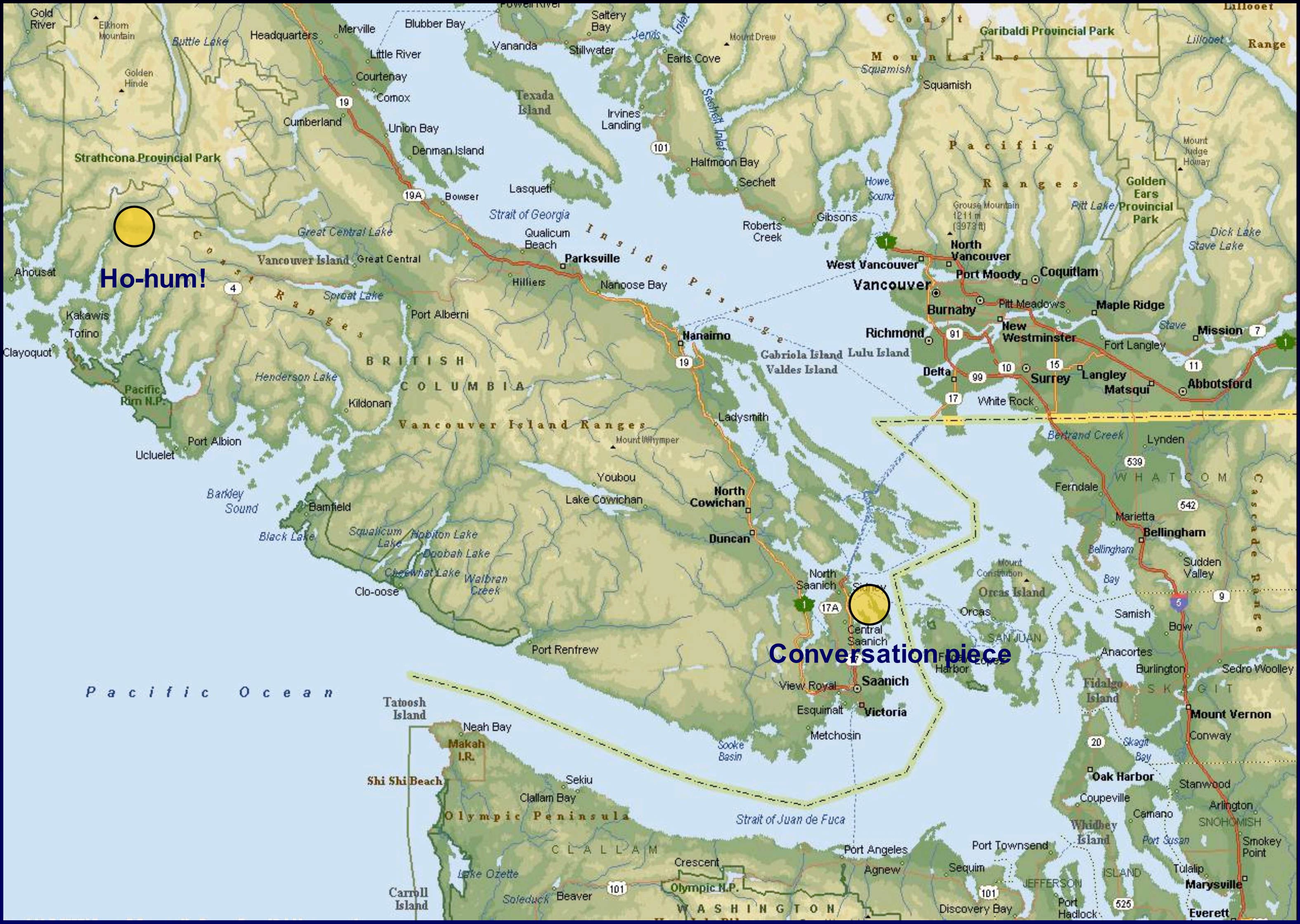
Magnitude 7



Magnitude 6


Minor losses
Major damage
Strathcona Provincial Park
Garibaldi Provincial Park
Strait of Georgia
Inside Passage
Vancouver Island Ranges
BRITISH COLUMBIA
Pacific Ocean
Strait of Juan de Fuca
Olympic Peninsula
WASHINGTON
Vancouver
North Vancouver
West Vancouver
Burnaby
Richmond
Surrey
Coquitlam
Port Moody
New Westminster
Maple Ridge
Mission
Abbotsford
Langley
Delta
White Rock
Squamish
Gibsons
Sechelt
Parksville
Nanaimo
Ladysmith
North Cowichan
Duncan
Saanich
Victoria
Esquimalt
View Royal
Sidney
Metchosin
Port Renfrew
Port Alberni
Tofino
Ucluelet
Bamfield
Courtenay
Comox
Cumberland
Qualicum Beach
Lake Cowichan
Bellingham
Lynden
Ferndale
Anacortes
Burlington
Mount Vernon
Oak Harbor
Port Angeles
Port Townsend
Sequim
Neah Bay
Marysville
Everett
Texada Island
Orcas Island
Friday Harbor
Whidbey Island
Pacific Rim N.P.
Olympic N.P.

Magnitude 4



Ho-hum!
Conversation piece
Gold River
Strathcona Provincial Park
Buttle Lake
Headquarters
Merville
Little River
Courtenay
Comox
Cumberland
Union Bay
Denman Island
Blubber Bay
Vananda
Texada Island
Saltery Bay
Stillwater
Earls Cove
Irvines Landing
Halfmoon Bay
Sechelt
Roberts Creek
Gibsons
Squamish
Garibaldi Provincial Park
Coast Mountains
Pacific Ranges
Golden Ears Provincial Park
Bowser
Lasqueti
Strait of Georgia
Qualicum Beach
Parksville
Inside Passage
Great Central Lake
Great Central
Vancouver Island
Ahousat
Hilliers
Nanoose Bay
Sproat Lake
Port Alberni
Kakawis
Tofino
Clayoquot
Pacific Rim N.P.
British Columbia
Henderson Lake
Kildonan
Nanaimo
Gabriola Island
Valdes Island
Lulu Island
West Vancouver
North Vancouver
Vancouver
Port Moody
Coquitlam
Burnaby
Pitt Meadows
Maple Ridge
New Westminster
Richmond
Mission
Fort Langley
Delta
Surrey
Langley
Matsqui
Abbotsford
White Rock
Vancouver Island Ranges
Ladysmith
Port Albion
Ucluelet
Barkley Sound
Bamfield
Youbou
Lake Cowichan
North Cowichan
Duncan
Lynden
Ferndale
Whatcom
Bellingham
Black Lake
Hobiton Lake
Nitinat Lake
Cheewhat Lake
Walbran Creek
Clo-oose
North Saanich
Central Saanich
Orcas Island
Orcas
San Juan
Samish
Bow
Sudden Valley
Port Renfrew
View Royal
Saanich
Esquimalt
Victoria
Metchosin
Sooke Basin
Anacortes
Burlington
Sedro Woolley
Fidalgo Island
Skagit
Mount Vernon
Conway
Pacific Ocean
Tatoosh Island
Neah Bay
Makah I.R.
Shi Shi Beach
Sekiu
Clallam Bay
Olympic Peninsula
Clallam
Strait of Juan de Fuca
Port Angeles
Agnew
Crescent
Olympic N.P.
Sequim
Port Townsend
Oak Harbor
Coupeville
Whidbey Island
Camano
Stanwood
Arlington
Snohomish
Smokey Point
Tulalip
Marysville
Everett
Lake Ozette
Carroll Island
Beaver
Soleduck
Washington
Jefferson
Port Hadlock
Discovery Bay
Island

Effects of strong earthquakes

- Ground shaking
- Tsunami
- Liquefaction
- Landslides
- Fire
- Aftershocks

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- **Ground shaking**
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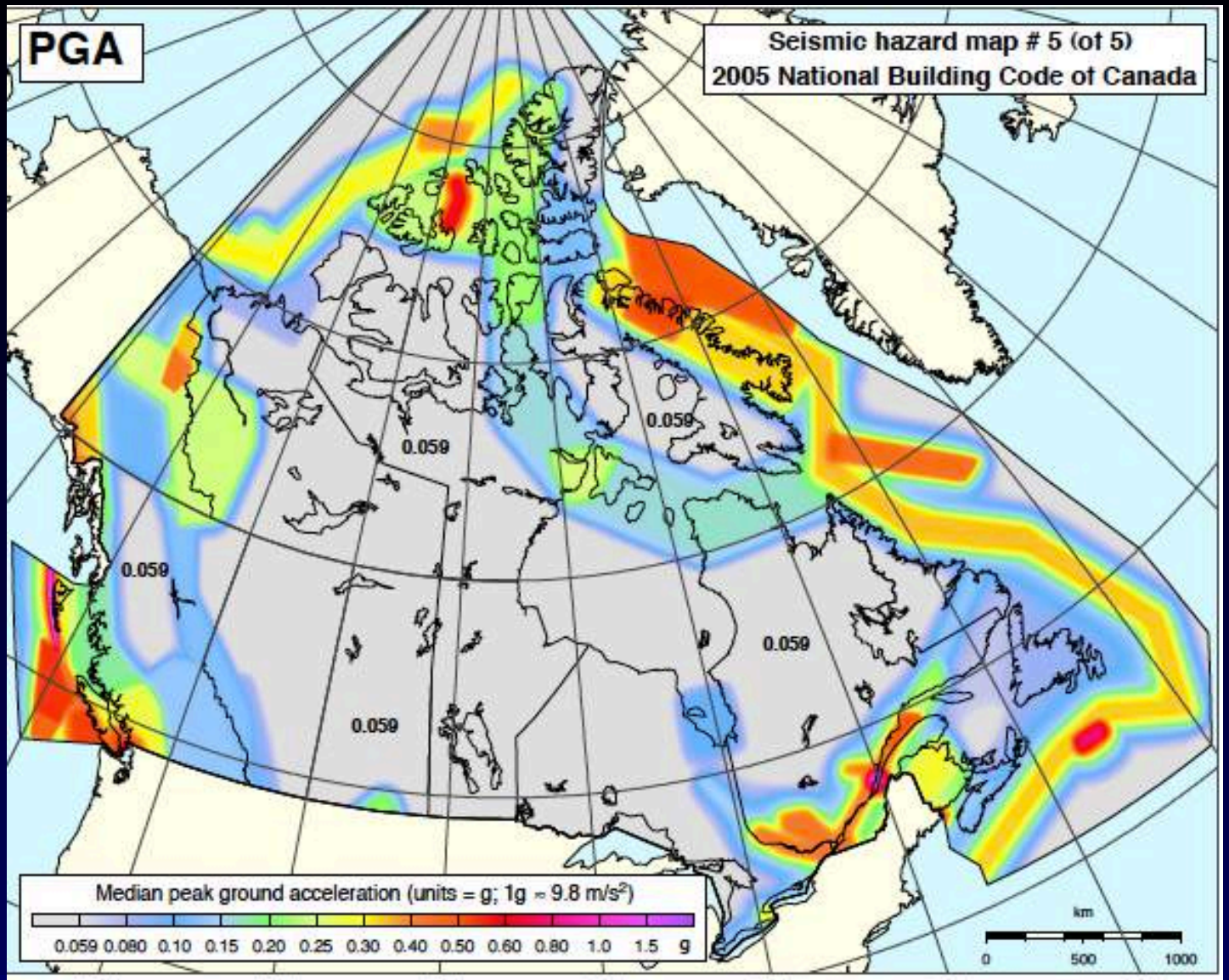
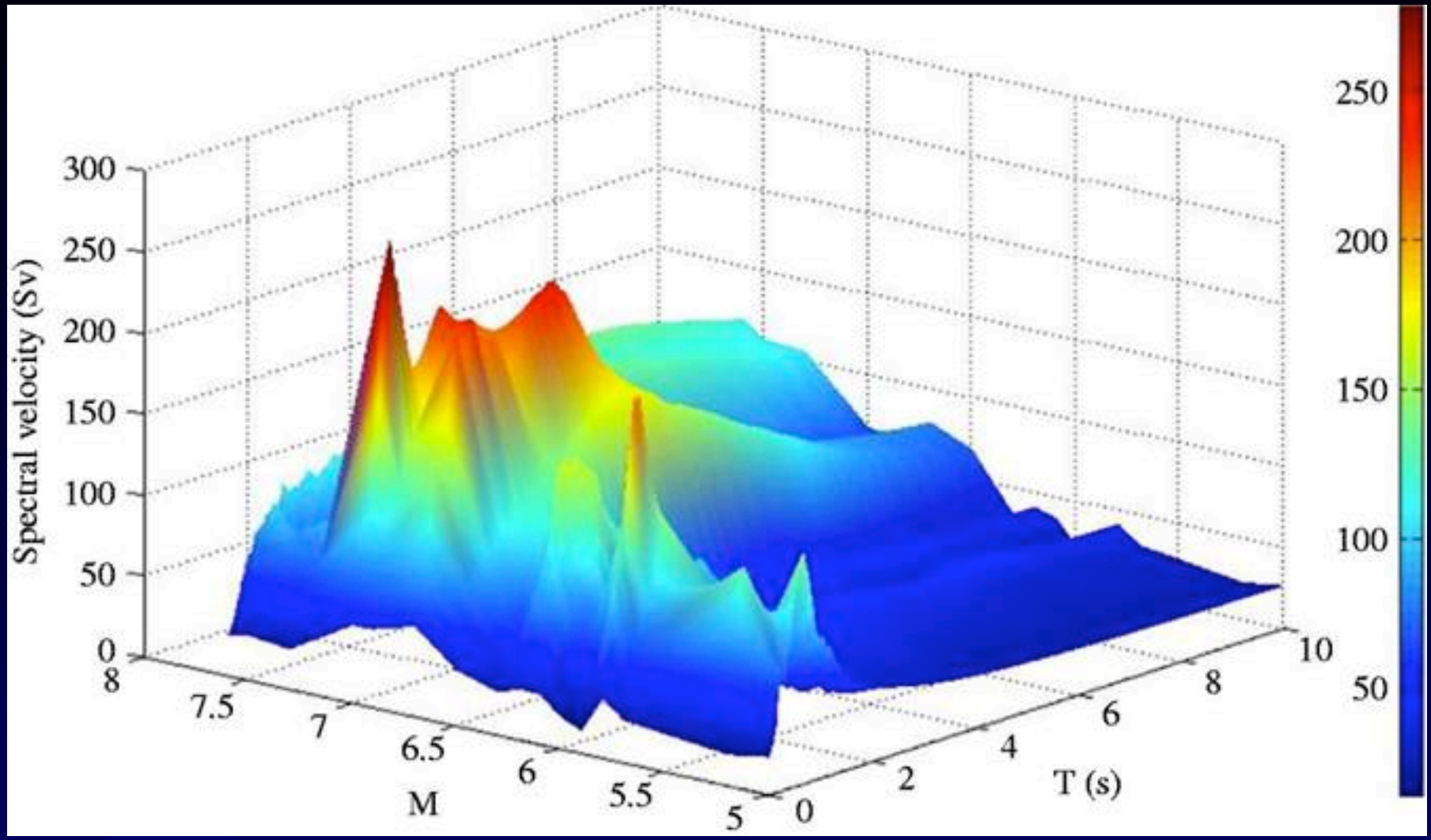
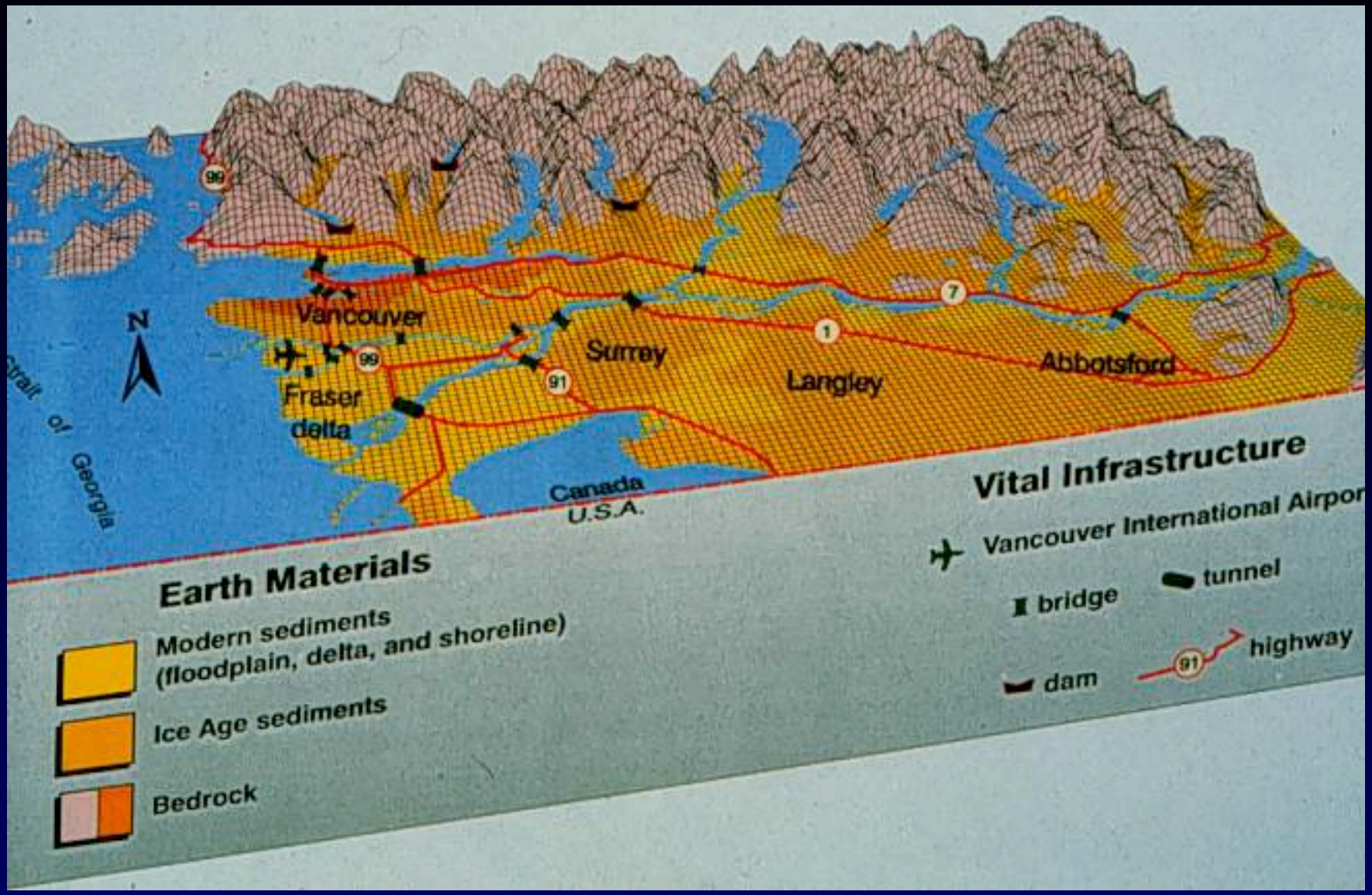


Peak ground acceleration at a probability of 2%/50 years for firm ground conditions (NBCC soil class C).

Ground motion depends on many things…

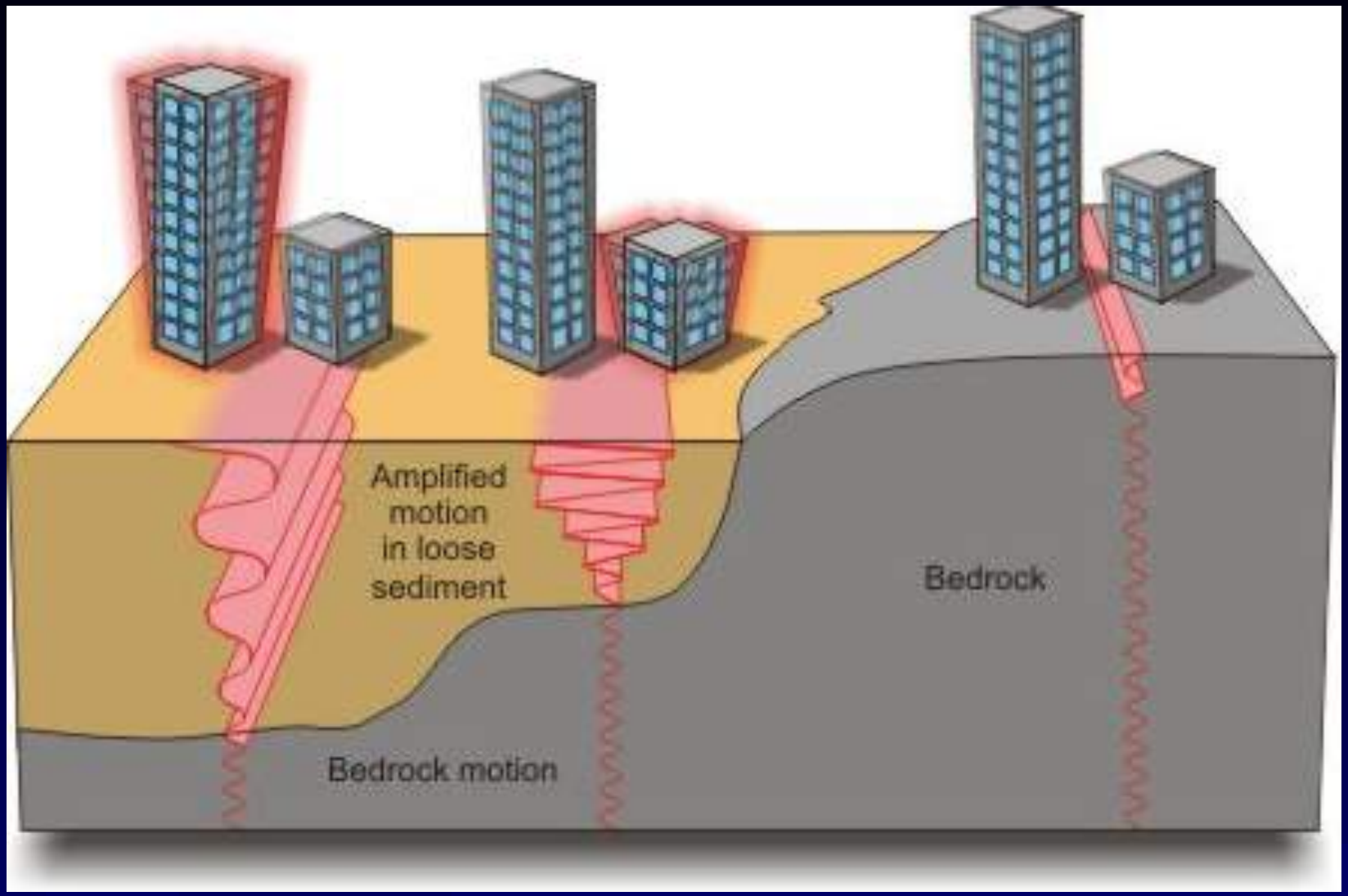


… including geology and topography



NRCan

Ground motion amplification



Clague and Turner, 2003

Effects of strong earthquakes

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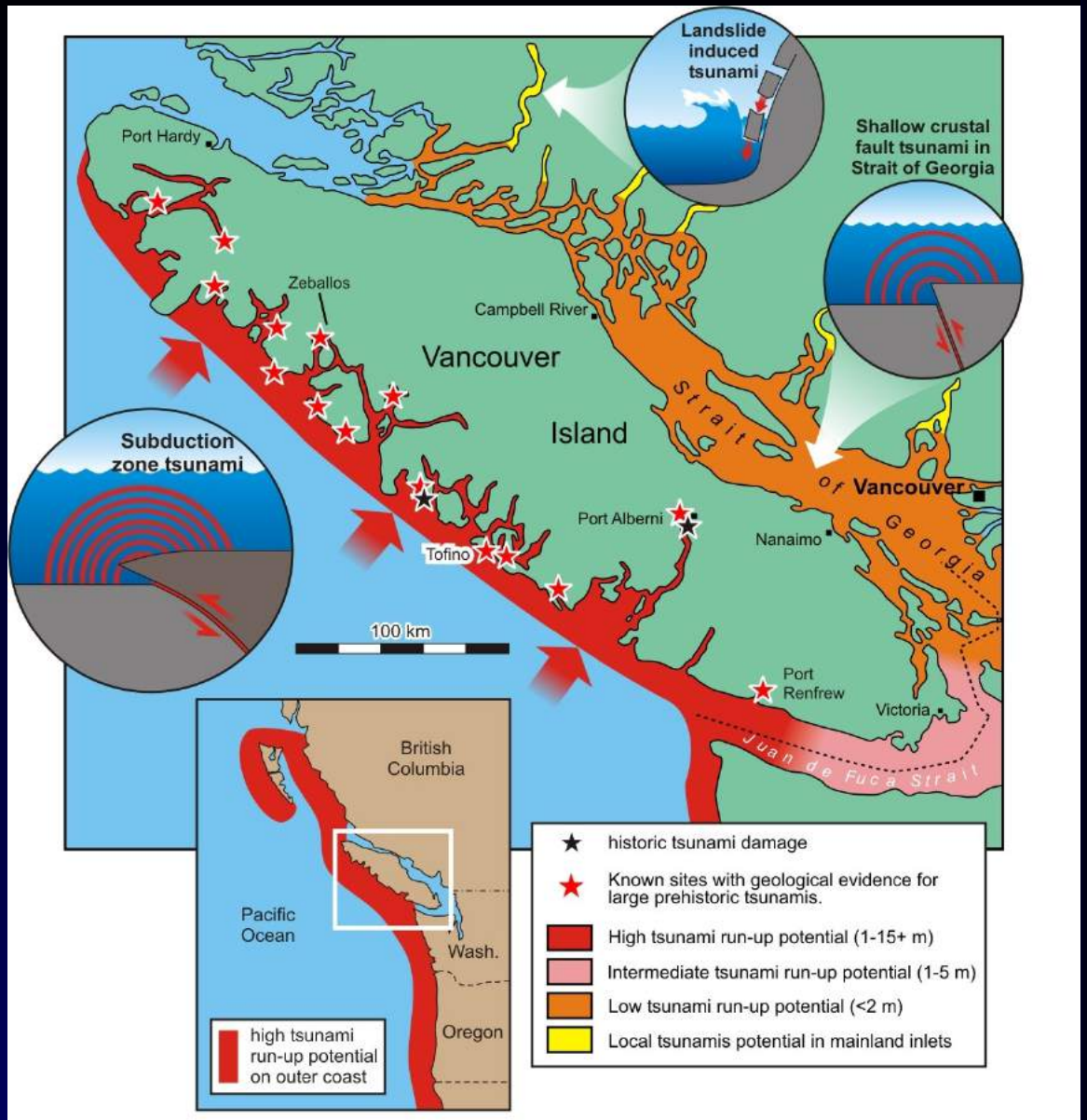
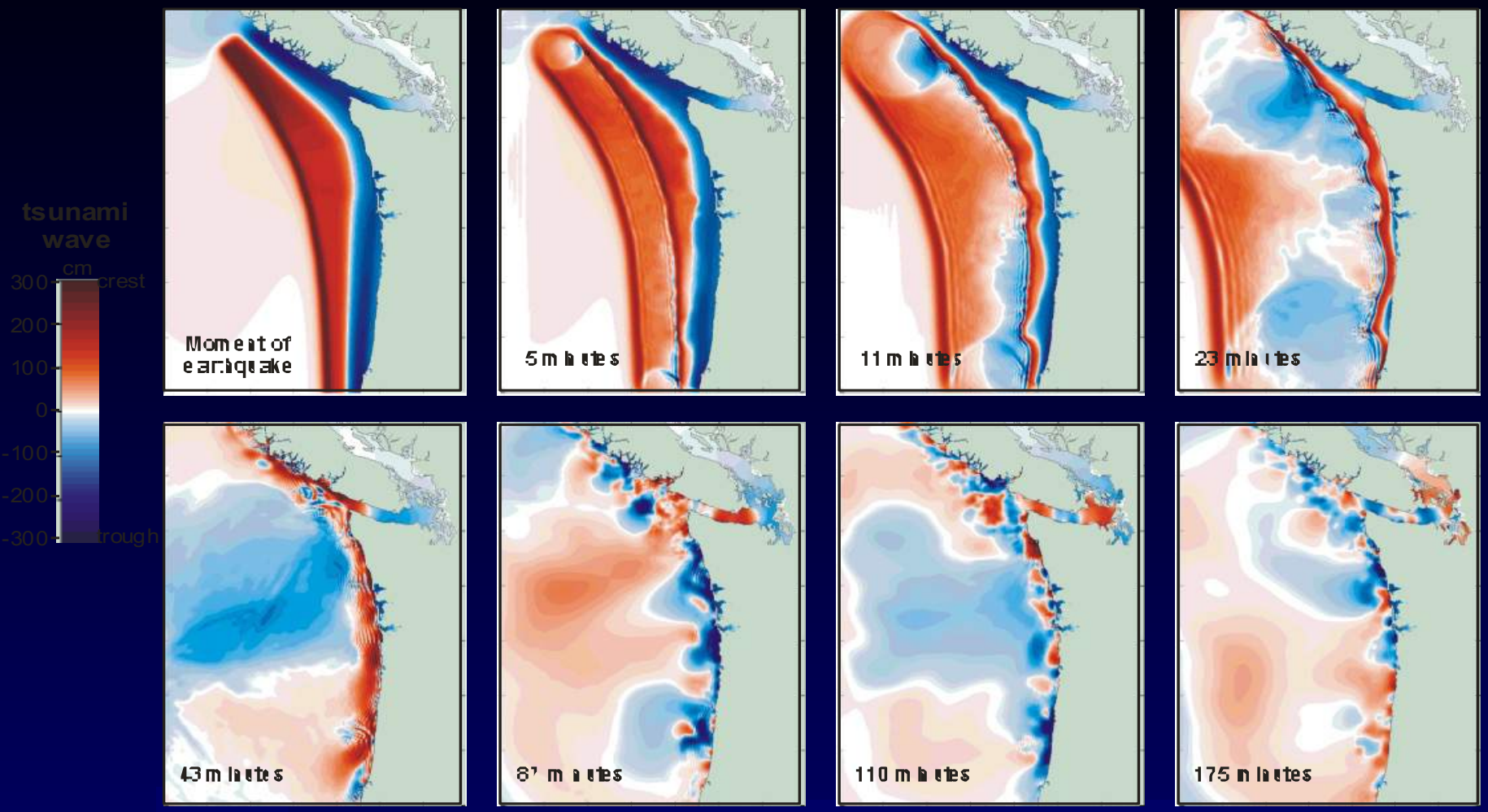

Landslide induced tsunami
Shallow crustal fault tsunami in Strait of Georgia
Subduction zone tsunami
Port Hardy
Zeballos
Campbell River
Vancouver Island
Strait of Georgia
Vancouver
Port Alberni
Nanaimo
Tofino
100 km
Port Renfrew
Victoria
Juan de Fuca Strait
British Columbia
Pacific Ocean
Wash.
Oregon
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

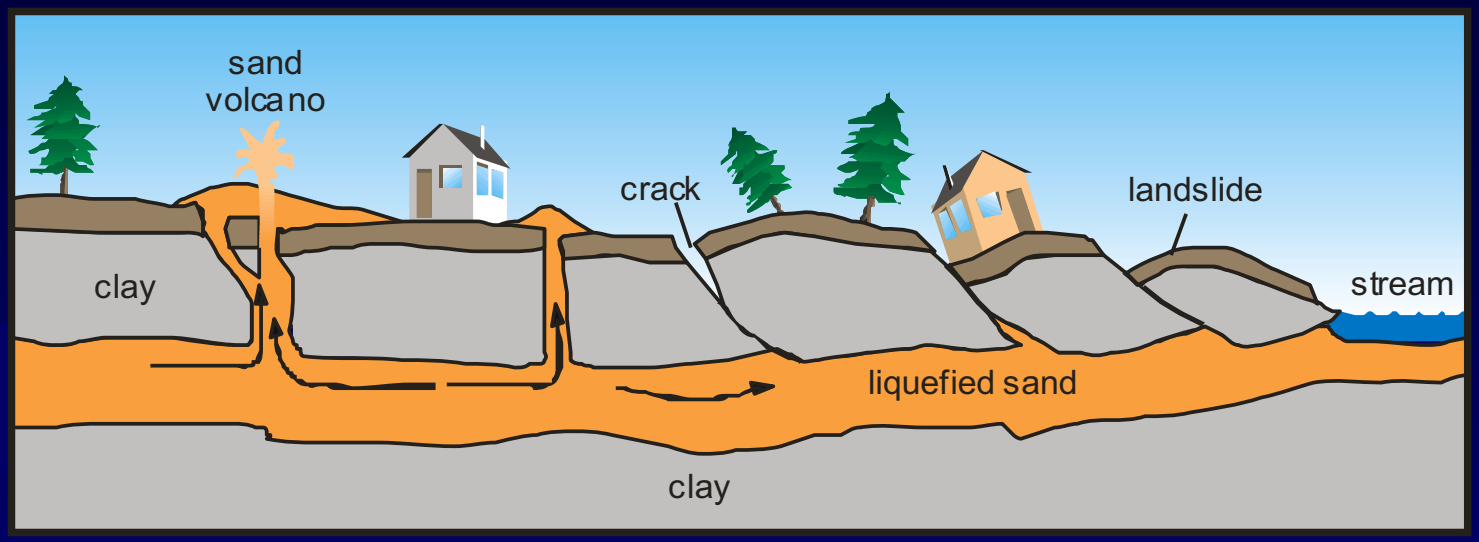
Tsunami


tsunami wave
cm
300
200
100
0
-100
-200
-300
crest
trough
Moment of earthquake
5 minutes
11 minutes
23 minutes
43 minutes
87 minutes
110 minutes
175 minutes

Effects of strong earthquakes

- Ground shaking
- Tsunami
- **Liquefaction**
- Landslides
- Fire
- Aftershocks

Liquefaction



Effects of strong earthquakes

- Ground shaking
- Liquefaction
- **Landslides**
- Fire
- Aftershocks

CBC

Duncan Wyllie

Effects of strong earthquakes

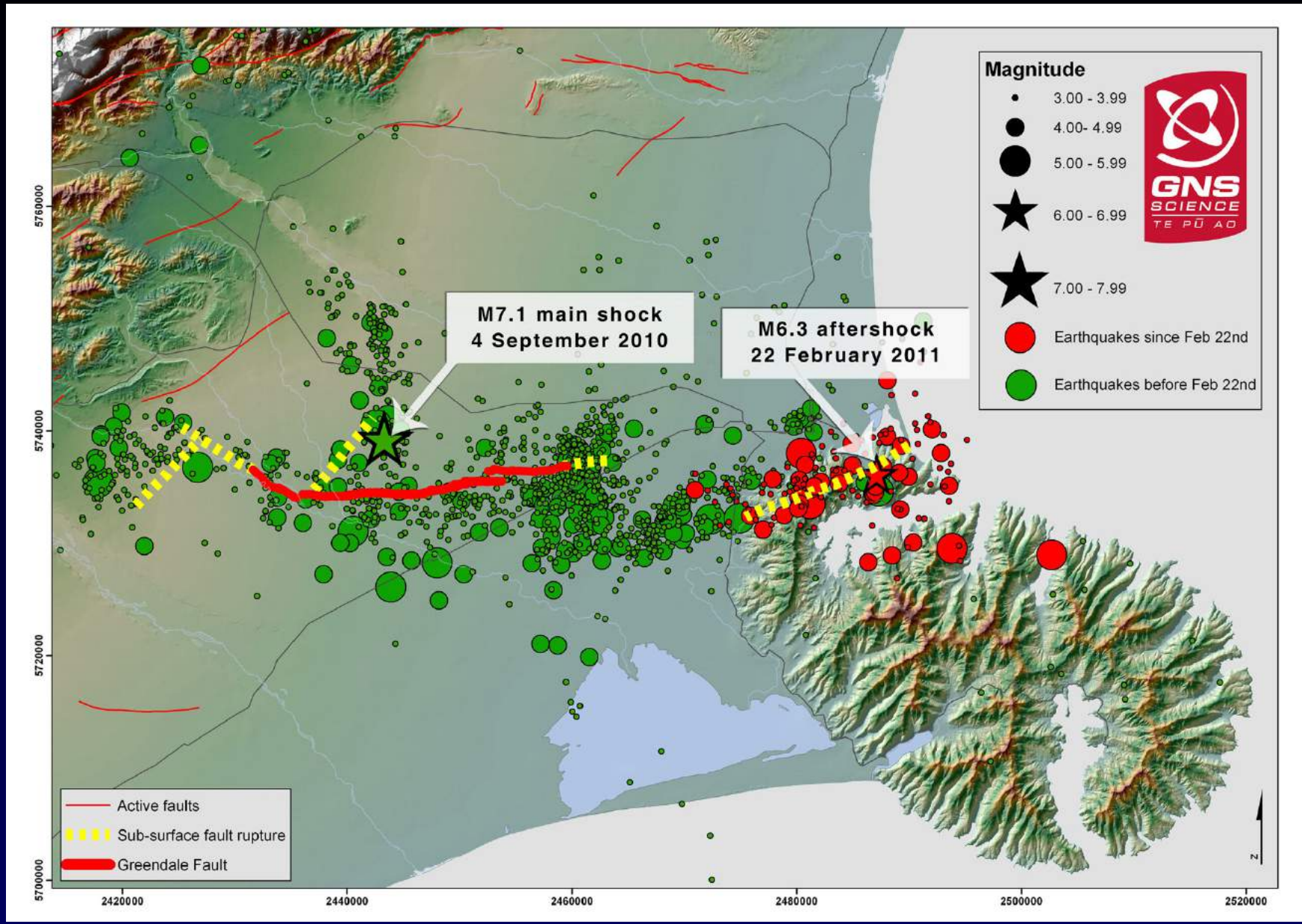
- Ground shaking
- Liquefaction
- Landslides
- **Fire**
- Aftershocks

San Francisco 1906

Kobe 1995

Effects of strong earthquakes

- Ground shaking
- Ground rupture
- Liquefaction
- Landslides
- Fire
- **Aftershocks**


Magnitude
3.00 - 3.99
4.00- 4.99
5.00 - 5.99
6.00 - 6.99
7.00 - 7.99
Earthquakes since Feb 22nd
Earthquakes before Feb 22nd
GNS SCIENCE TE PŪ AO
M7.1 main shock
4 September 2010
M6.3 aftershock
22 February 2011
Active faults
Sub-surface fault rupture
Greendale Fault
5760000
5740000
5720000
5700000
2420000
2440000
2460000
2480000
2500000
2520000
N


Questions