# Seismic hazard and seismic risk in Canada - a perspective for the insurance industry

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For ICLR workshop Toronto, 20110121



Natural Resources Canada
Ressources naturelles Canada

CANADA 1842 GEOLOGICAL SURVEY - COMMISSION GEOLOGIQUE

# Plan for Talk

- Introduction
- Effects of minor Val-des-Bois earthquake of June 23rd
- Effects of major September 3rd New Zealand earthquake
- Risk reduction through National Building code
- Canada's national seismic hazard maps
- Future risk mitigation and role of insurance industry

**Key messages**

• getting to know you – I don't know a lot about the details of the insurance industry, and you probably don't know a lot about earthquakes

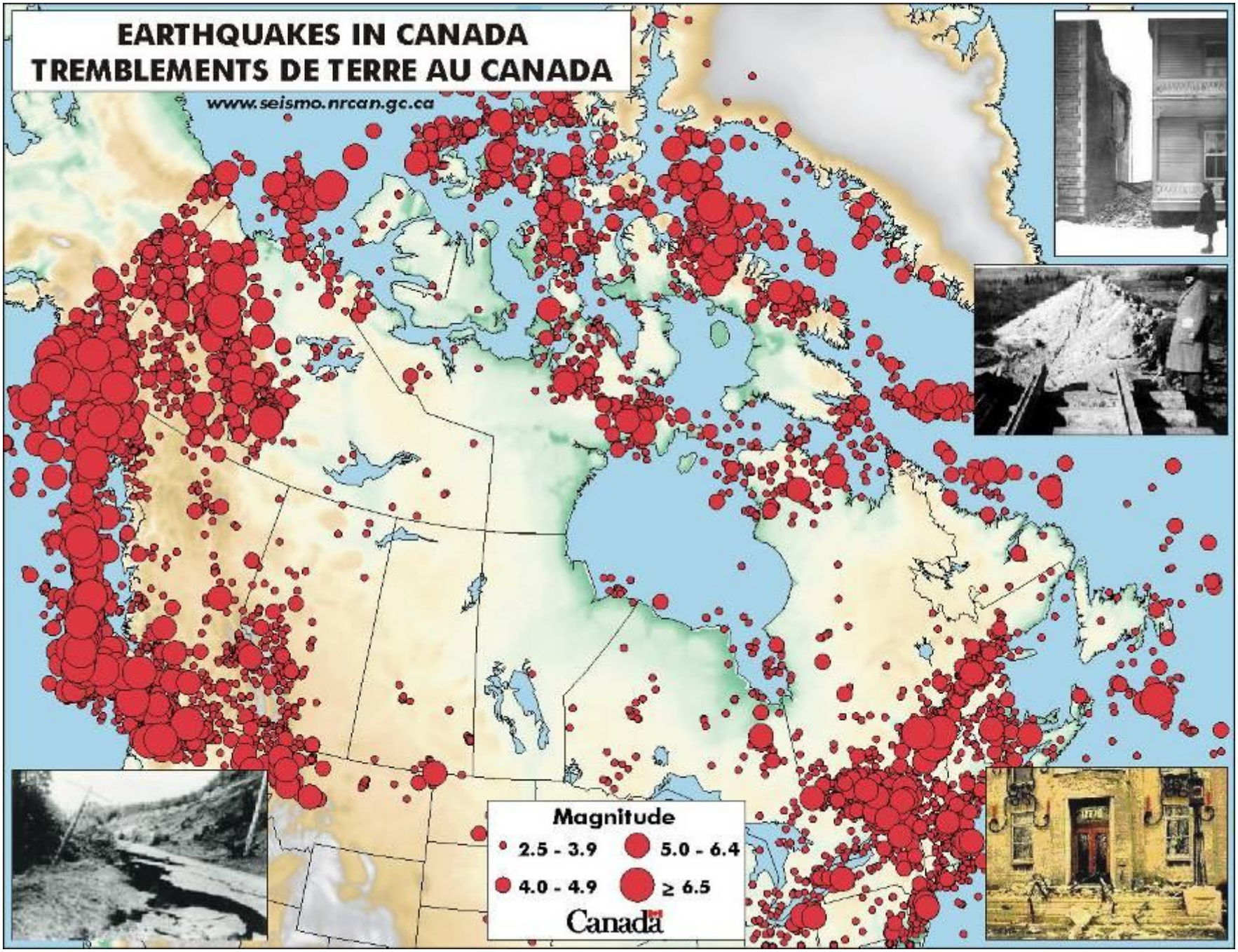
• An earthquake disaster will happen to a Canadian city

• The effects on buildings are somewhat predictable

• Building codes can mitigate some losses

• The consequences for recovery are somewhat unpredictable

• Preparing for earthquakes can help reduce losses

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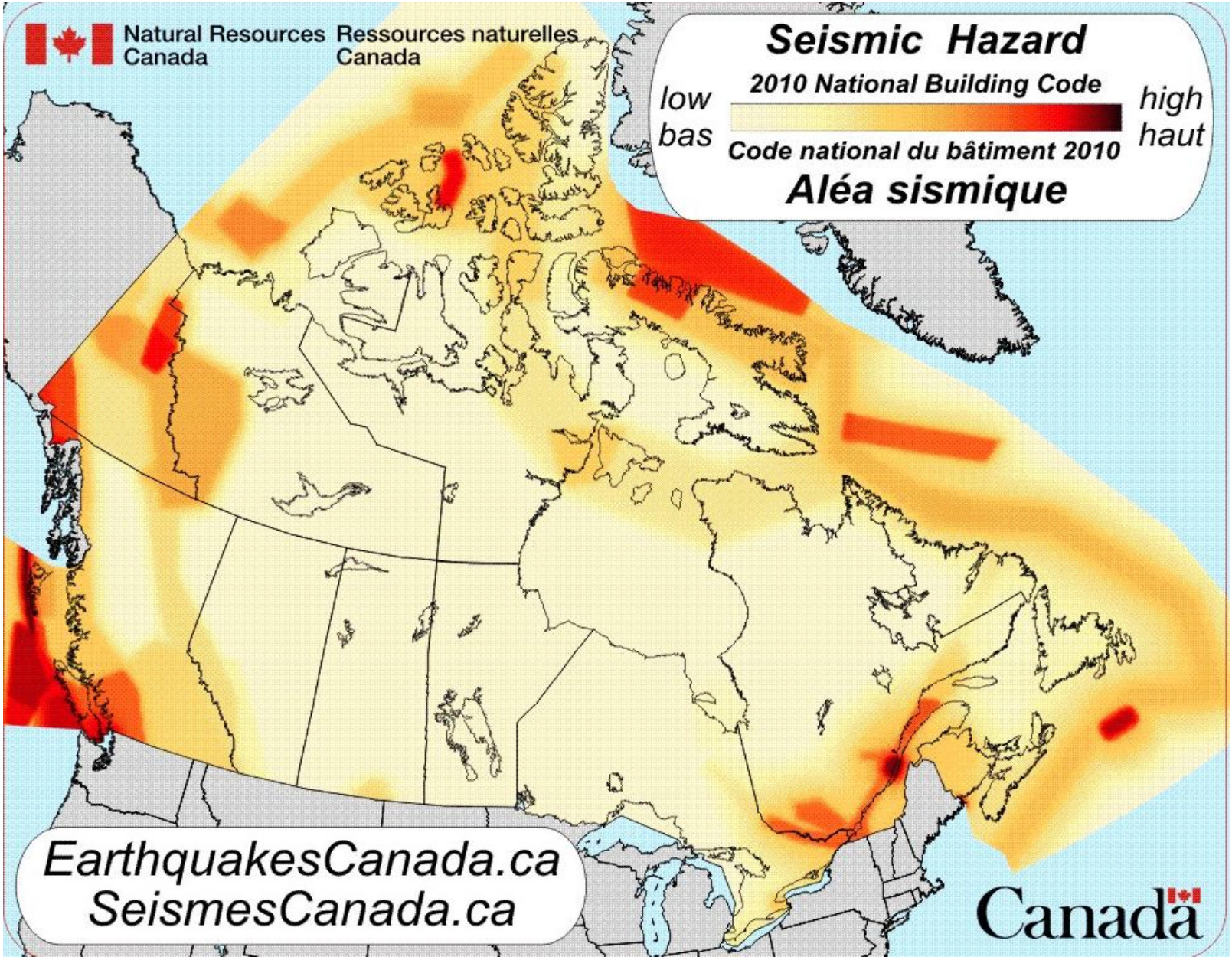


Seismic hazard design values at a probability of 2%/50 years for building design

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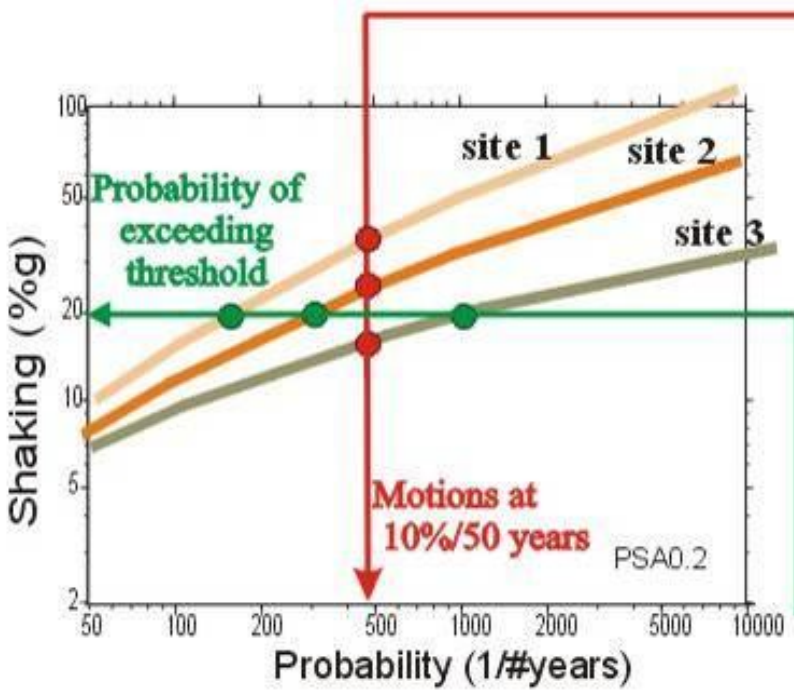
There are two ways of viewing the hazard curves for a number of sites

- constant probability (vertical line) or
- constant shaking (horizontal line).

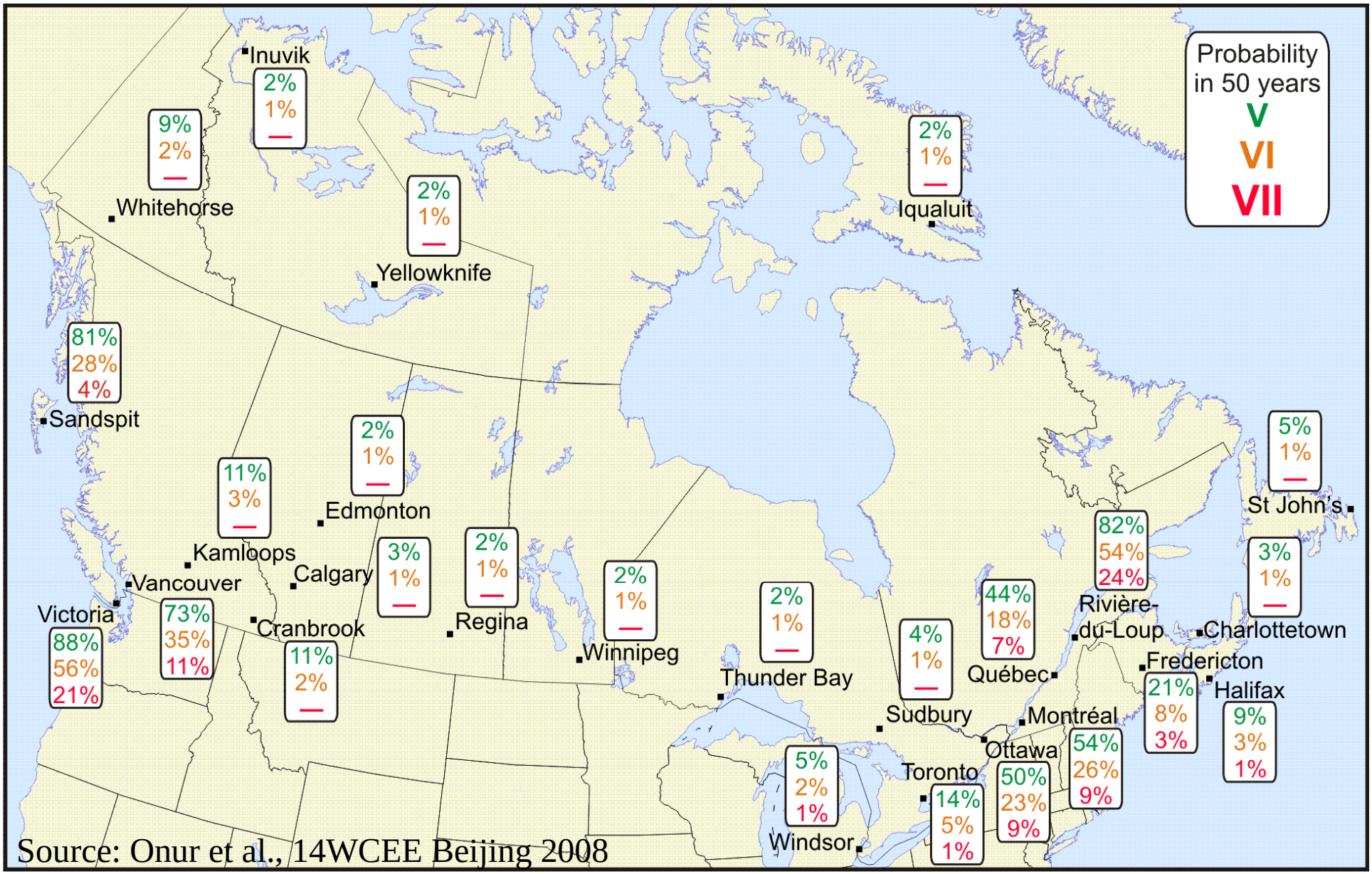
The constant probability values produce the maps most useful to engineers

The constant shaking threshold maps, are probably of most interest to insurers




shaking at constant probability maps

probability of exceeding shaking threshold maps




→Better-than-even chance that a Canadian municipality will be strongly shaken and damaged in the next few decades

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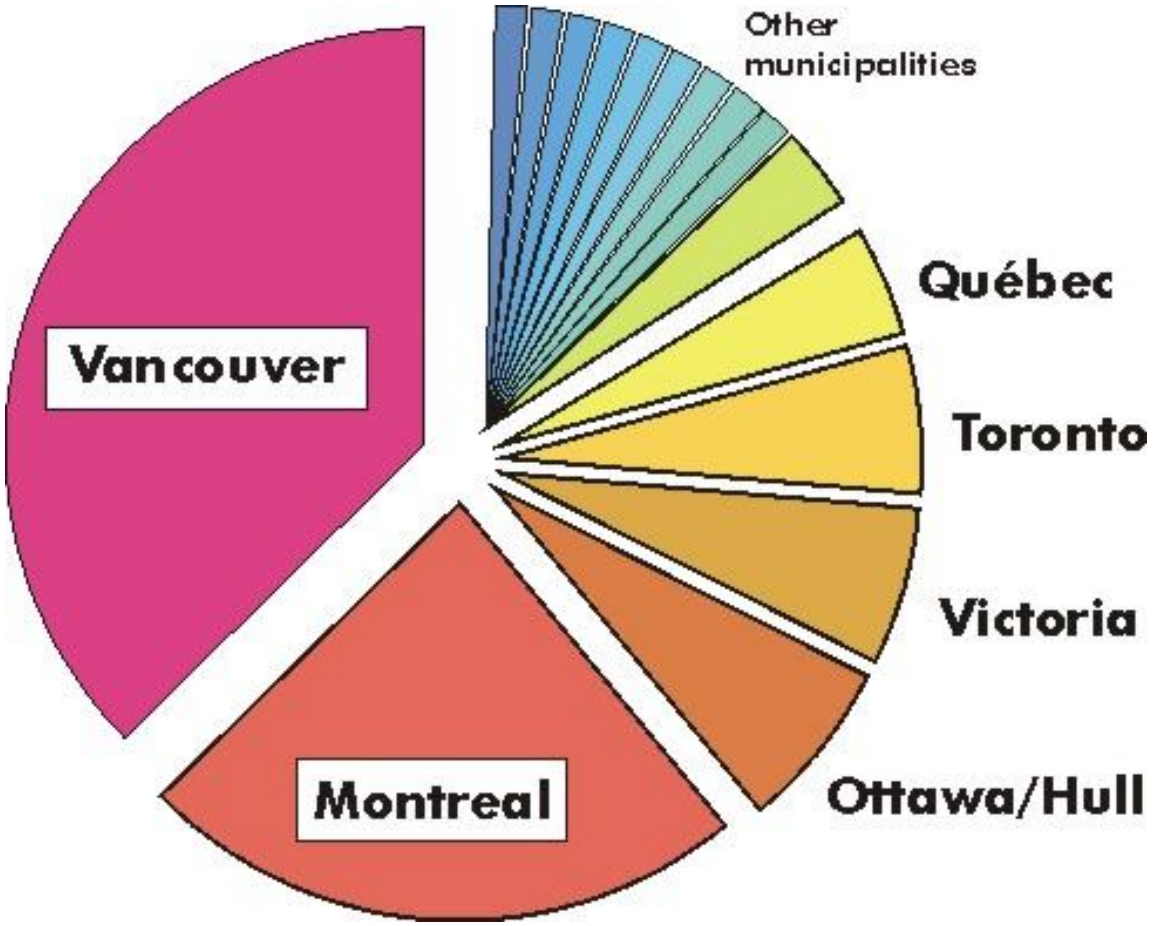
# Earthquake risk distribution
## – not all the risk is in the west



# Estimated intensity for Scenario Mw 6.8 earthquake

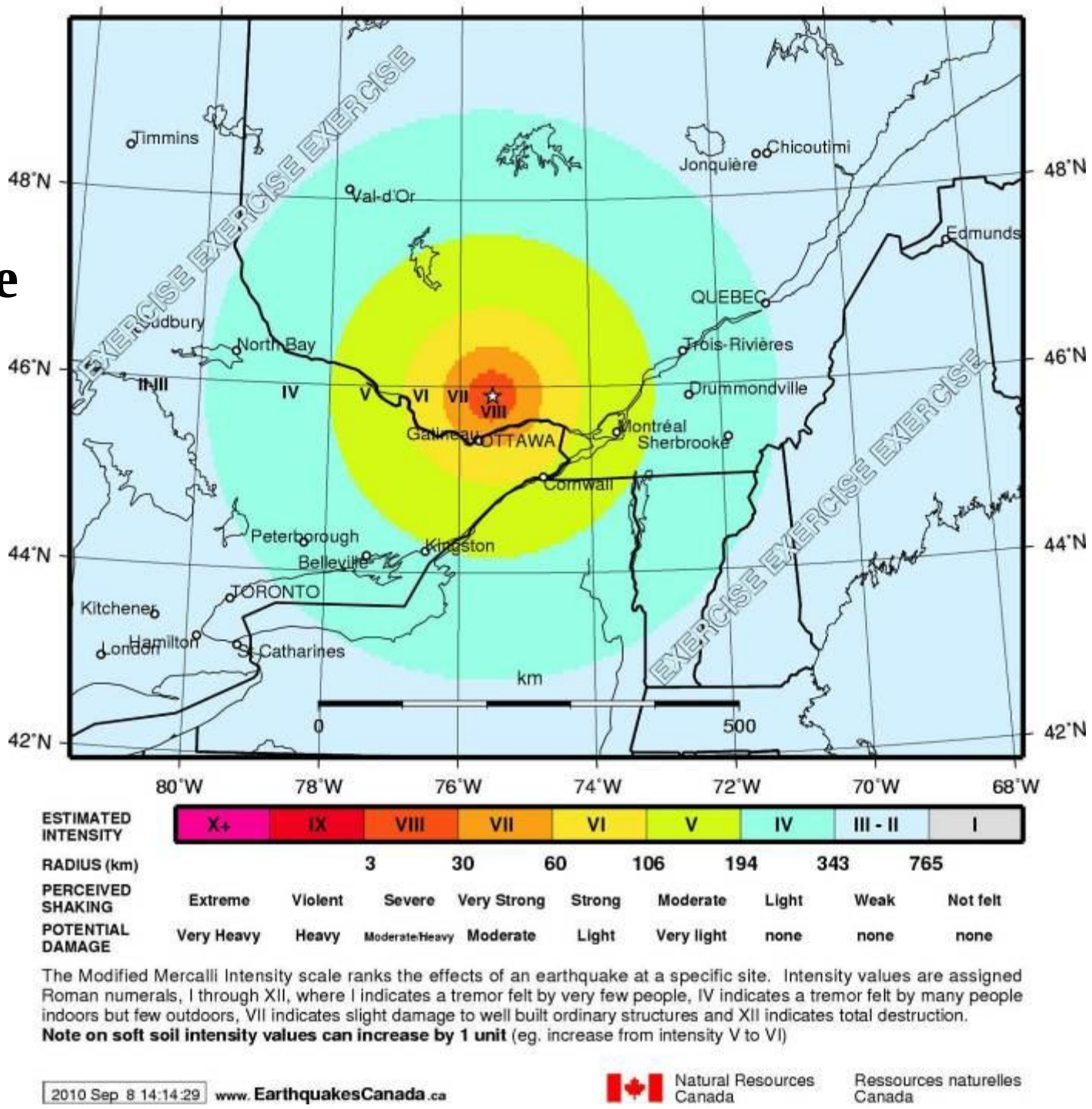
Epicentre at 45.9N 75.5W

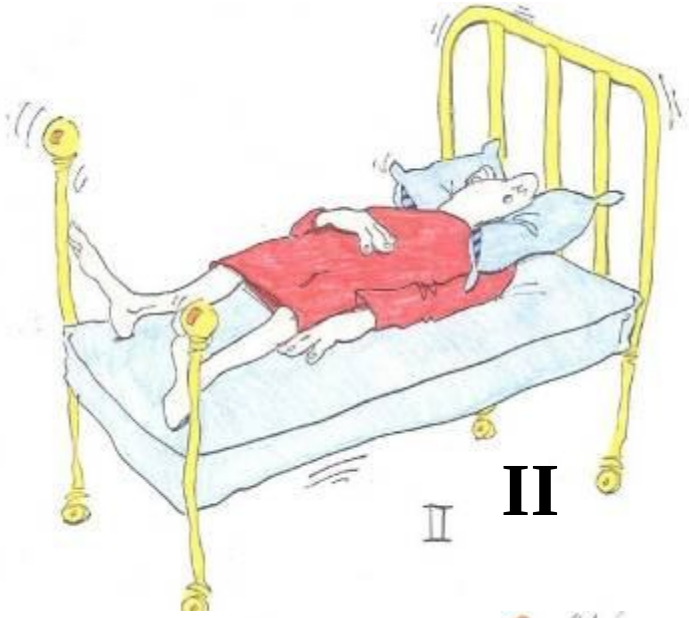
depth = 20 km

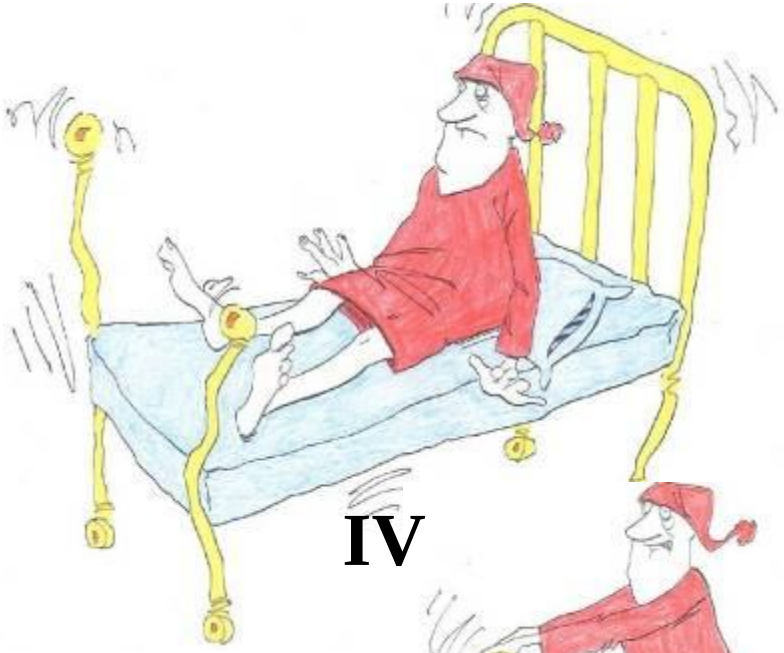
Atkinson-Boore 1995 relation for Class C soil

Epicentre: 7-20 sec of strong shaking

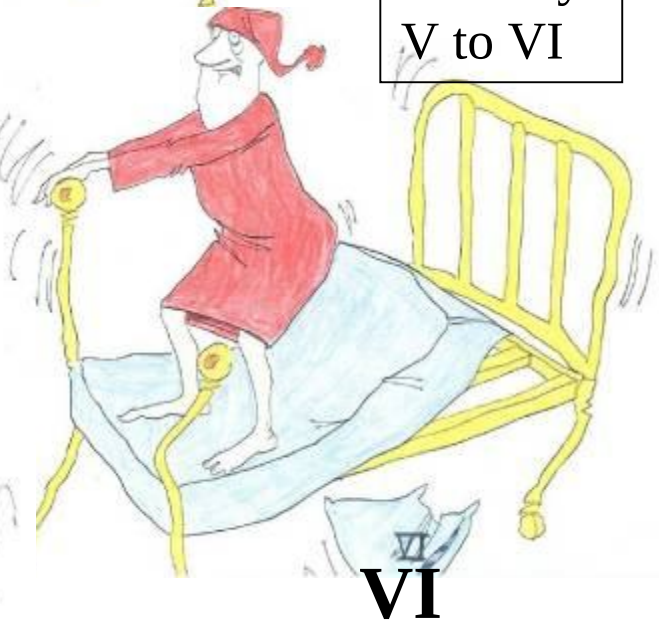
Shaking arrives:-
Ottawa T+14 sec
Montreal T+40 sec
Toronto T+2 min
Halifax T+5 min



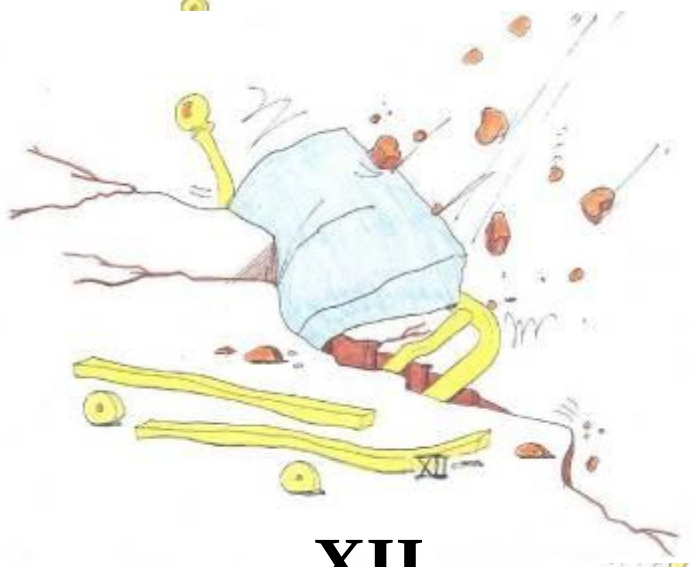



For Val-des-Bois, Ottawa mostly reported intensity V to VI




# Shaking intensity Modified Mercalli scale





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Two recent 2010 earthquakes are relevant

Magnitude 5.0 June 23 Val-des-Bois, Quebec

Magnitude 7.1 Sept 4 Christchurch, New Zealand

Let's learn a little about those earthquakes…..

(We won't spend much time on the Haiti and Chile earthquakes – there's a fine report Paul Kovacs prepared for the Lloyds meeting)

# Val-des-Bois, Québec, Earthquake of June 23, 2010

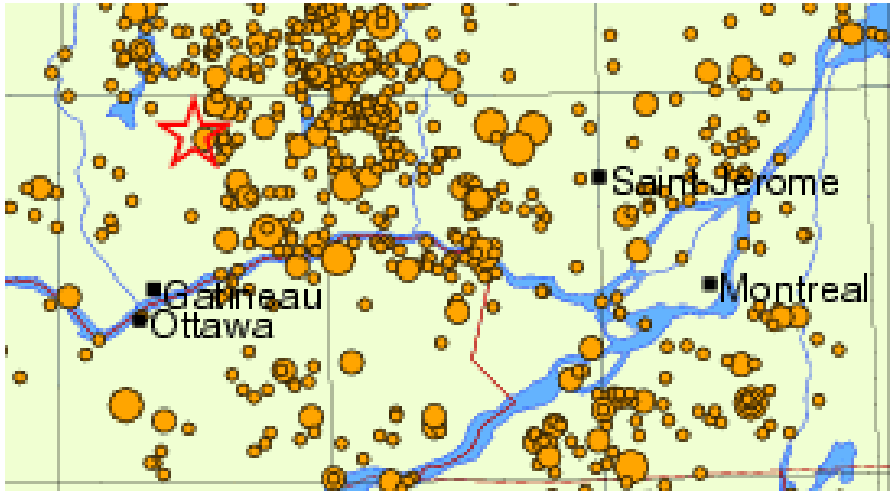
1:41 pm EDT June 23rd 2010

Magnitude (Mw) 5.0

55 km NNE of Ottawa

Earthquake notifications sent to critical infrastructure operators within 6 minutes

Largest aftershock happened at T+6 hours, mN=3.3




## The bottom line

**Bad news:** Strongest shaking in Ottawa's history

**Good News:** Much weaker than the current earthquake designs

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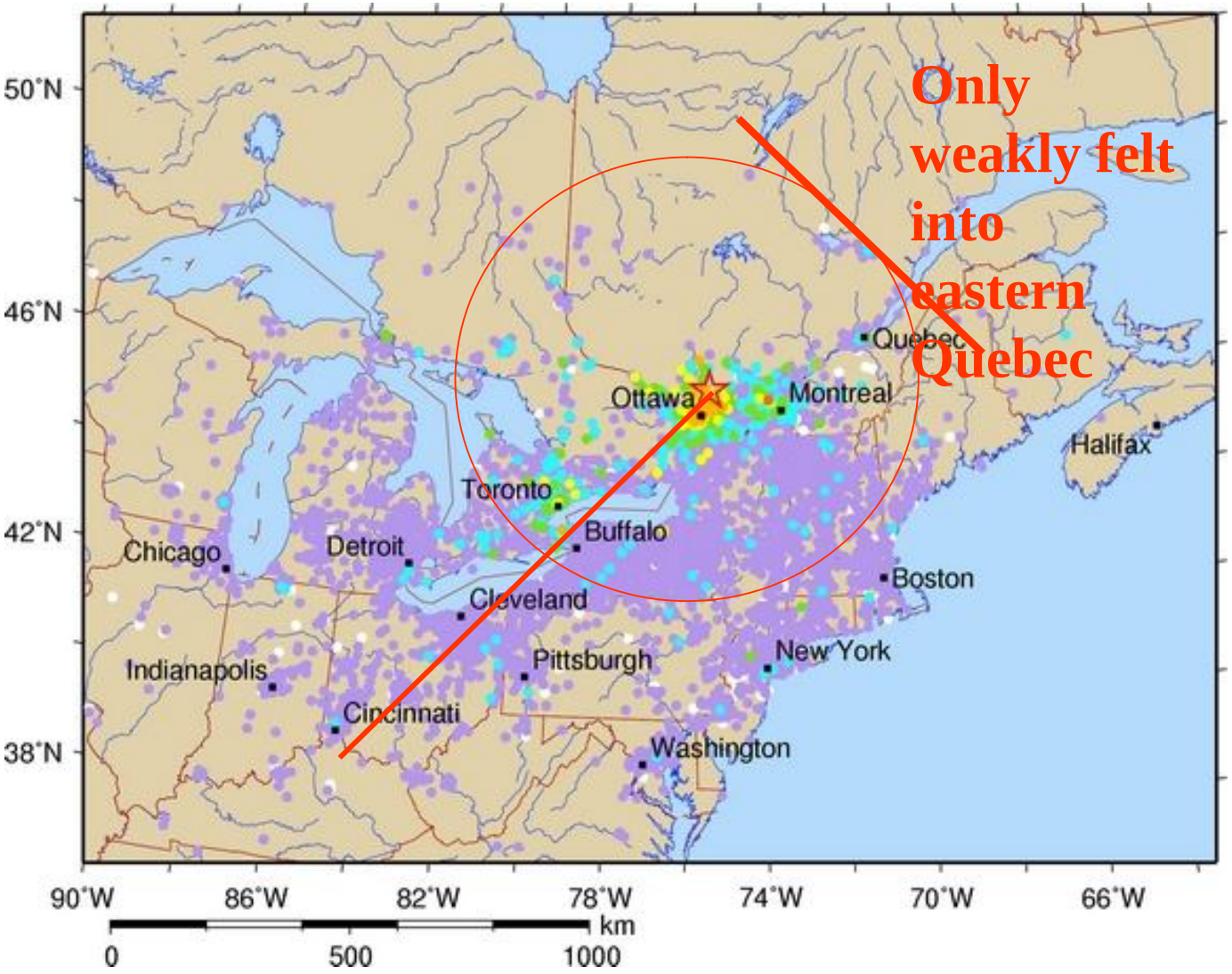
**Total felt area** (potentially felt by about 19 million people)

Web reports from 59,000 people to “Did You Feel It?”

Felt much farther to the southwest than to the northeast

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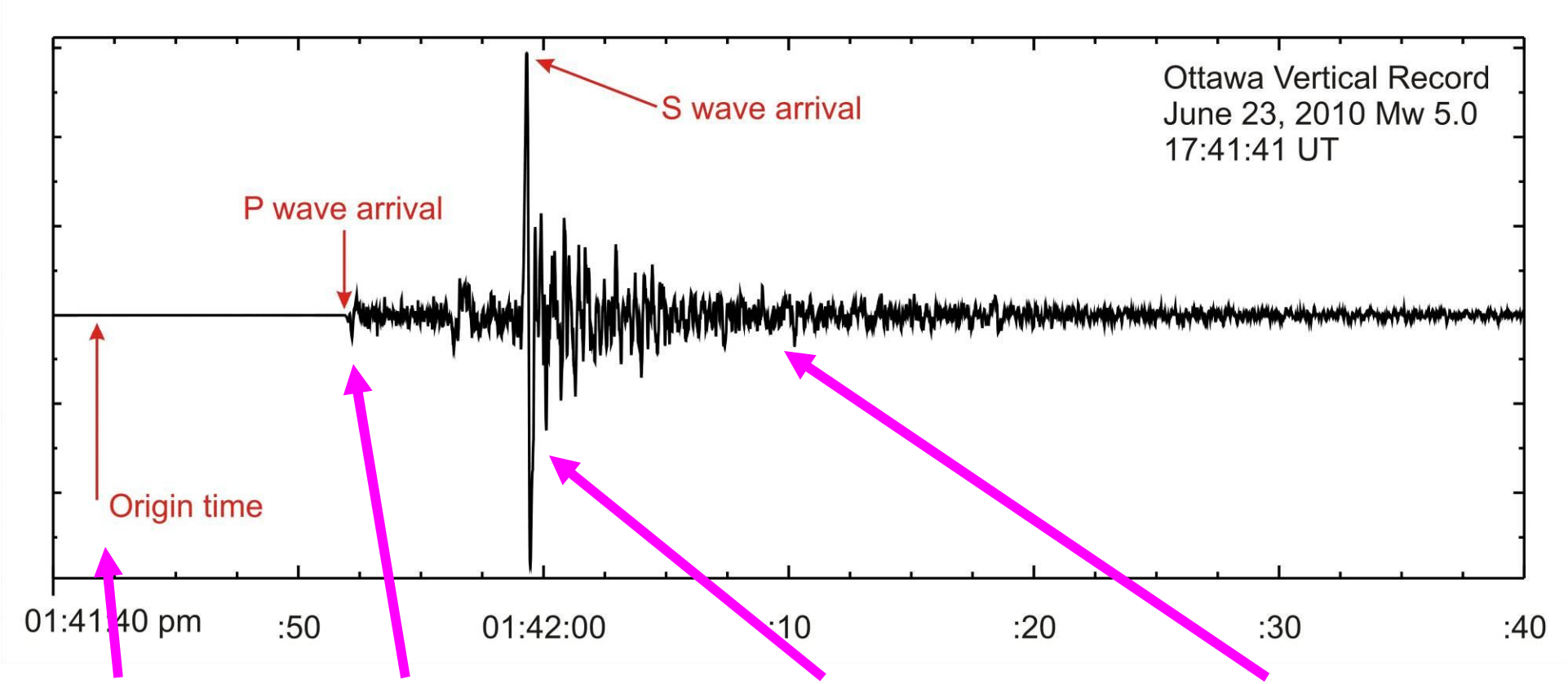
# What was recorded in Ottawa?




The Origin time (01:41:41 pm local time) is the actual time the earthquake started

The P (or Primary) waves travel at about 6 km/second and take roughly 10 seconds to arrive. These may or may not have been noticed by local residents as light shaking or noise prior to the arrival of the S (Secondary) waves

Secondary waves arrive 7 seconds after the P, are much larger in amplitude, and it is these waves that would have generated the strong shaking that was widely felt

The amplitude dies off fairly quickly, being significantly lower just 10 seconds after the start of the S waves

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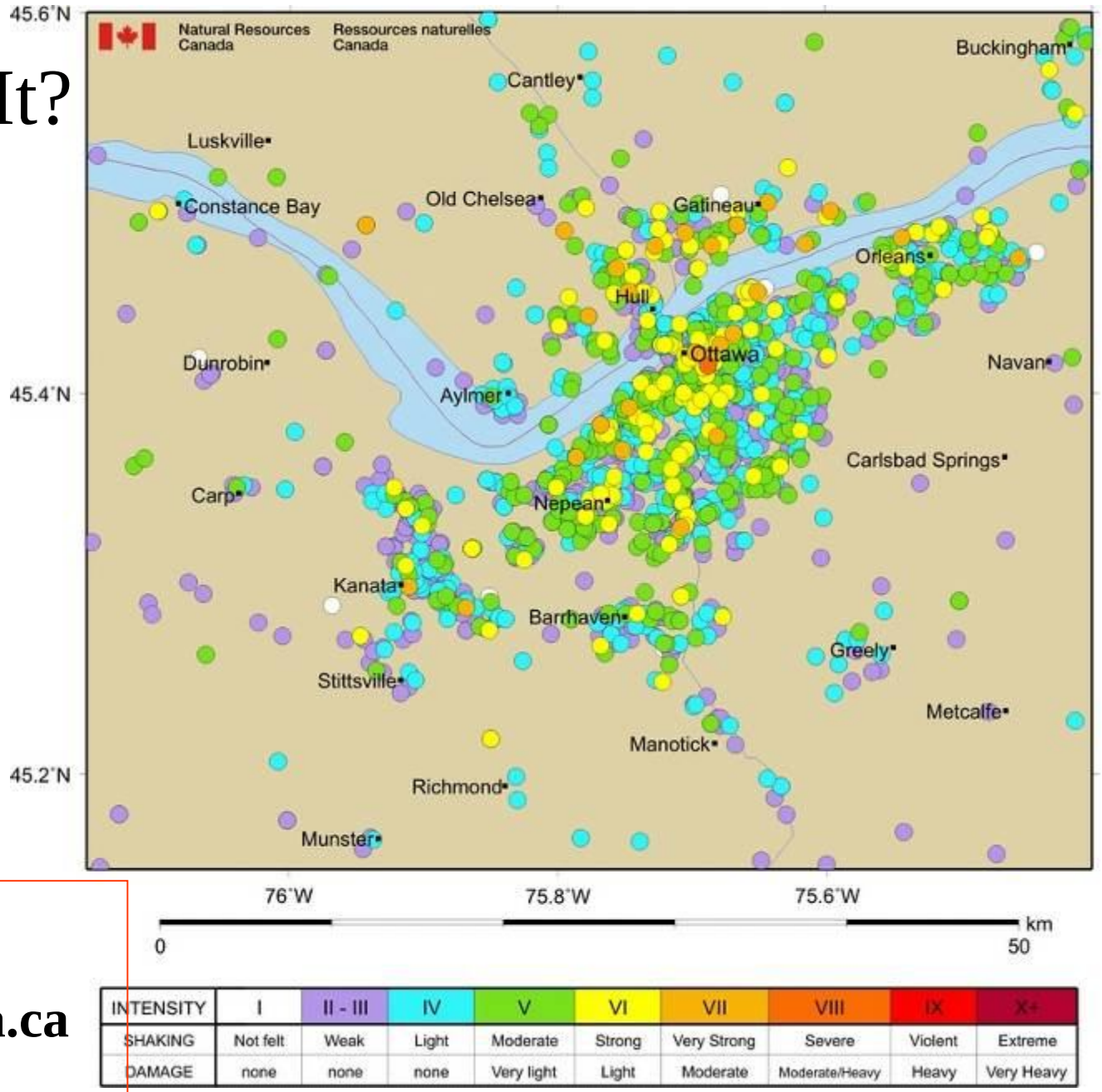
# Did You Feel It?

automatically assesses reports of

## Intensity

which is the strength of shaking at each place

(not the same as the magnitude of the earthquake)




| INTENSITY | I | II - III | IV | V | VI | VII | VIII | IX | X+ |
|---|---|---|---|---|---|---|---|---|---|
| SHAKING | Not felt | Weak | Light | Moderate | Strong | Very Strong | Severe | Violent | Extreme |
| DAMAGE | none | none | none | Very light | Light | Moderate | Moderate/Heavy | Heavy | Very Heavy |

Web questionnaire at

**EarthquakesCanada.ca**

We'd still like your input!

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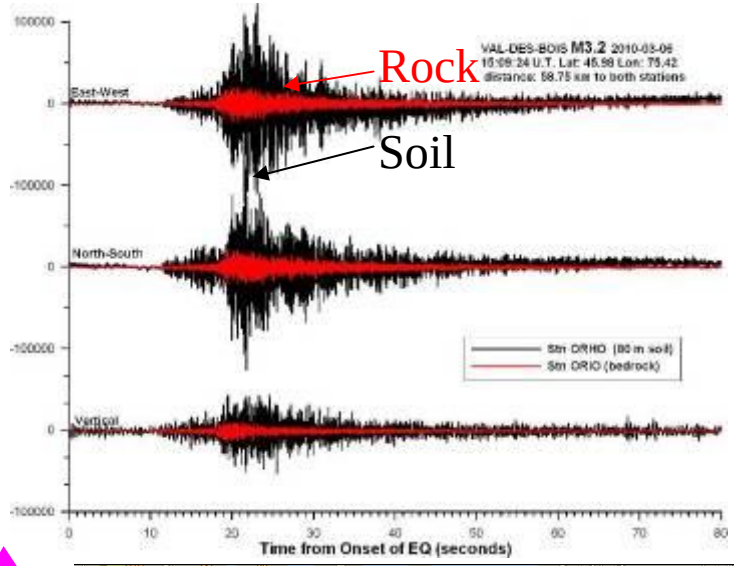
# Details of felt intensity

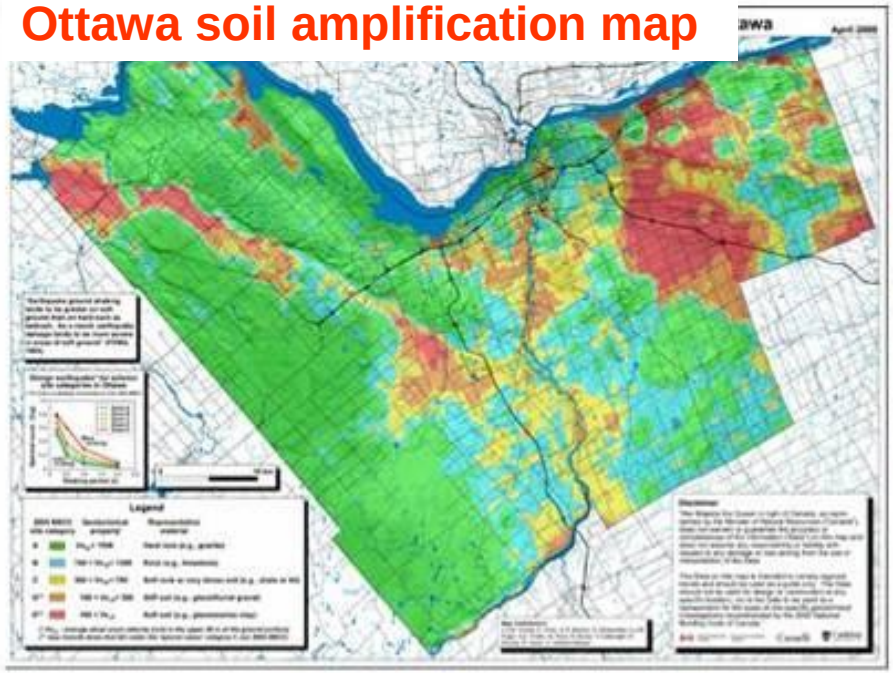
Intensity varies with soil conditions – strongest on thick clay

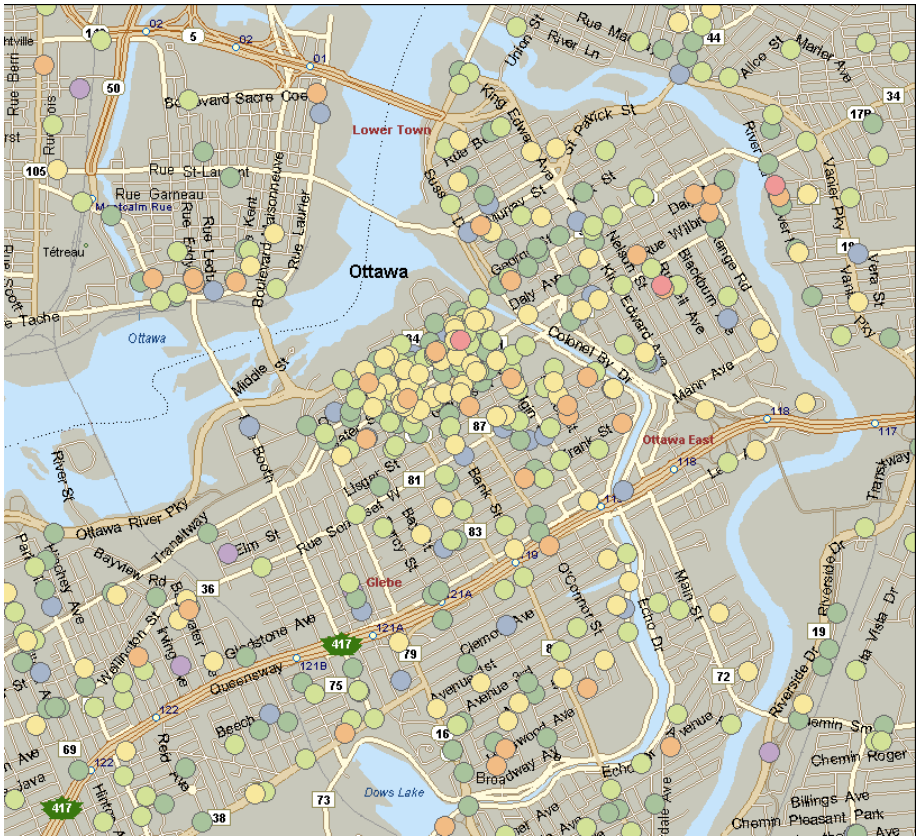
Geocoding of postal codes allows assignment to city blocks

Hope to match to and test soil amplification maps of Ottawa prepared by GSC & Carleton Univ

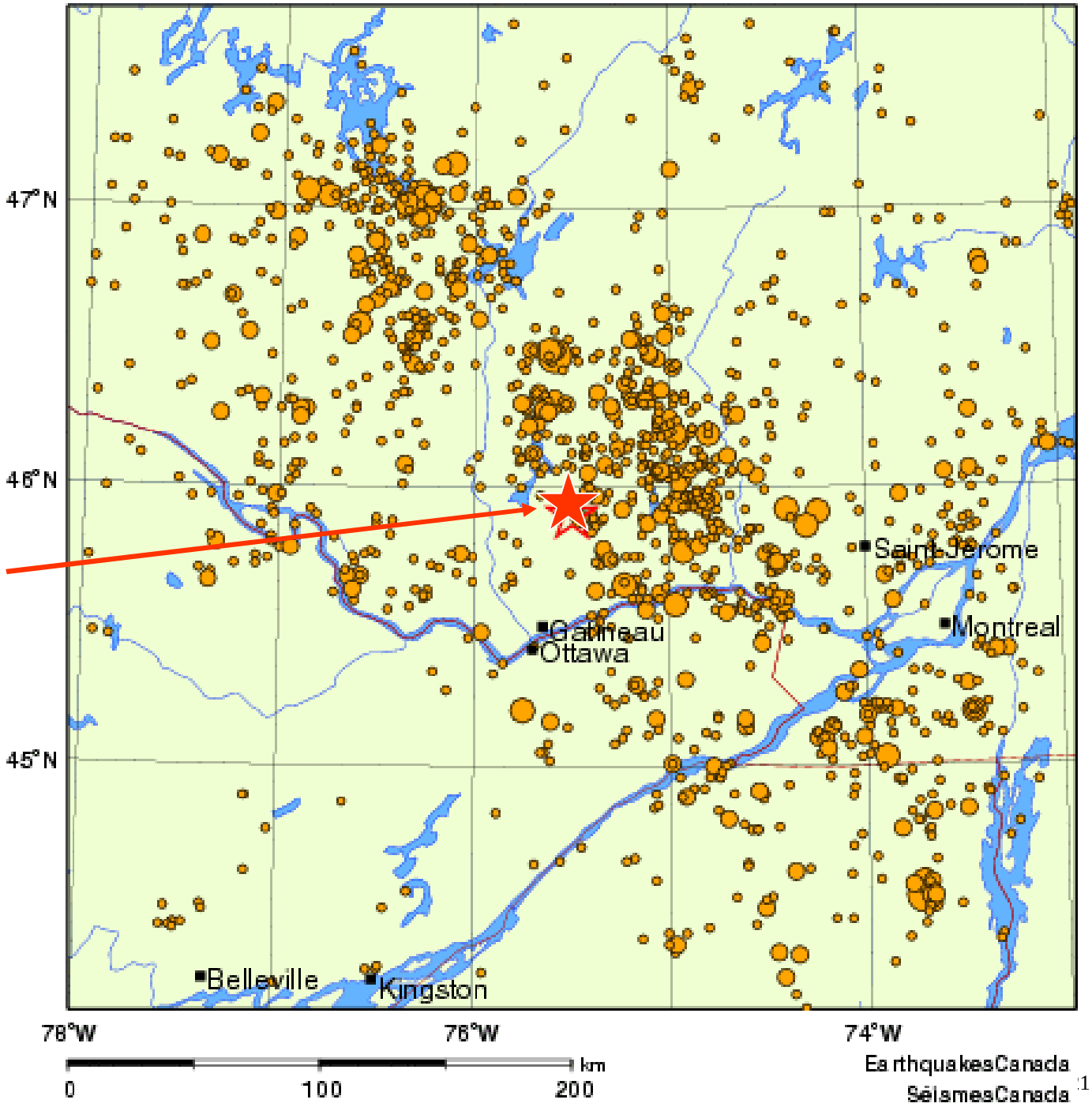



**Ottawa soil amplification map**





# Ottawa is in/near an earthquake zone




Earthquakes magnitude 2.0 and larger, 1980 - present

# Earthquake history of Ottawa

## Earthquakes that have shaken Ottawa

| Date | Lat N | Long W | Magnitude | Distance from Ottawa (km) | Predicted PGA (g) |
|---|---|---|---|---|---|
| 18610712 | 45.40 | 75.40 | 5.0 | 22 | **0.038** |
| 19440905 | 44.97 | 74.90 | 5.6 | 71 | **0.035** |
| 19140210 | 46.00 | 75.00 | 5.5 | 91 | 0.025 |
| 17320916 | 45.50 | 73.60 | 5.8 | 162 | 0.021 |
| 18160909 | 45.50 | 73.60 | 5.7 | 162 | 0.019 |
| 19351101 | 46.78 | 79.07 | 6.2 | 310 | 0.019 |
| 18701020 | 47.40 | 70.50 | 6.5 | 467 | 0.018 |
| 19881125 | 48.11 | 71.18 | 6.5 | 464 | 0.018 |
| 18931127 | 45.50 | 73.30 | 5.7 | 185 | 0.016 |

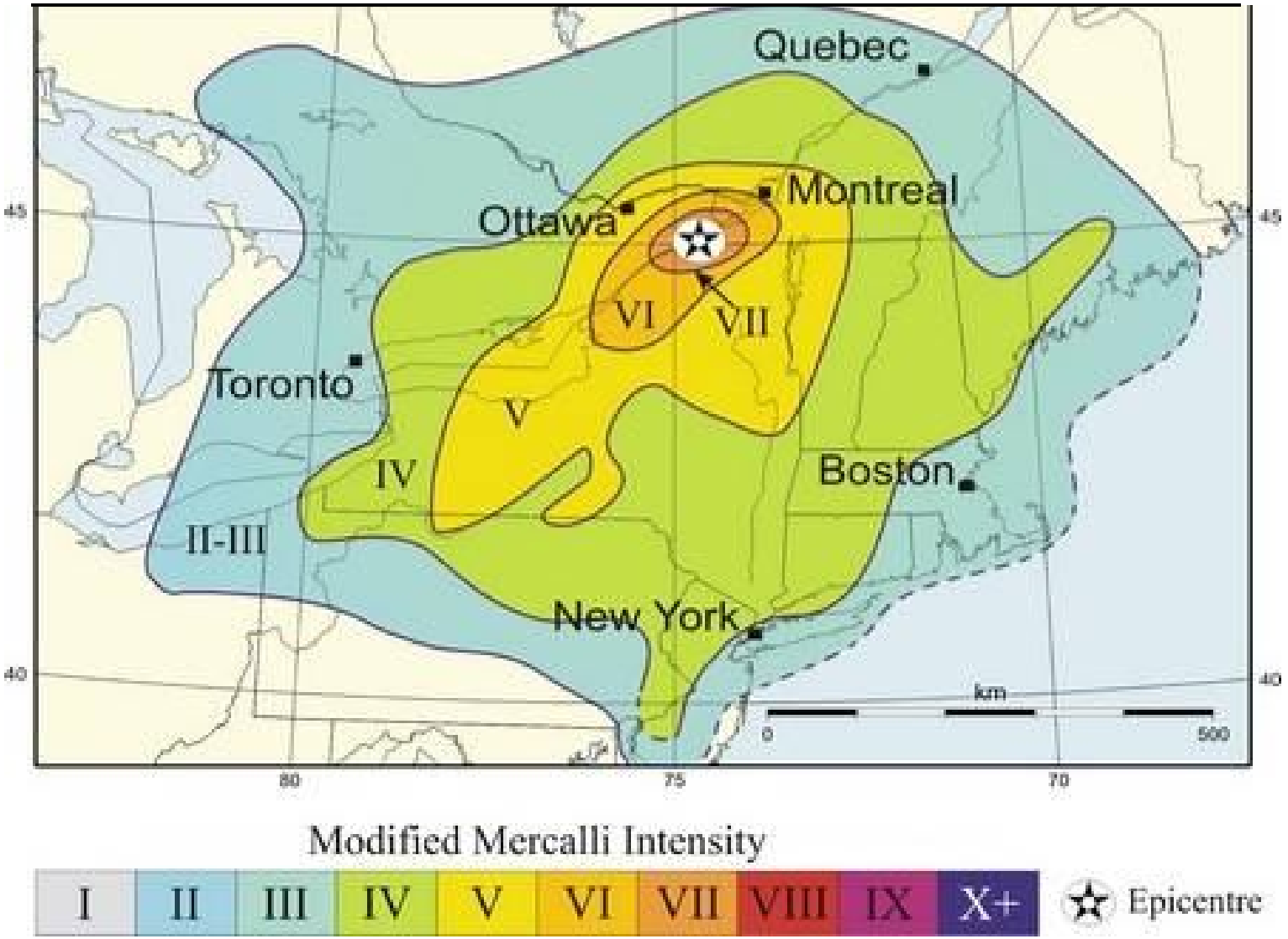
~5% Val-des-Bois*

~2% Thurso Feb 2006**

* More on soft soil

** Less in the west-end

# Cornwall 1944 M 5.8

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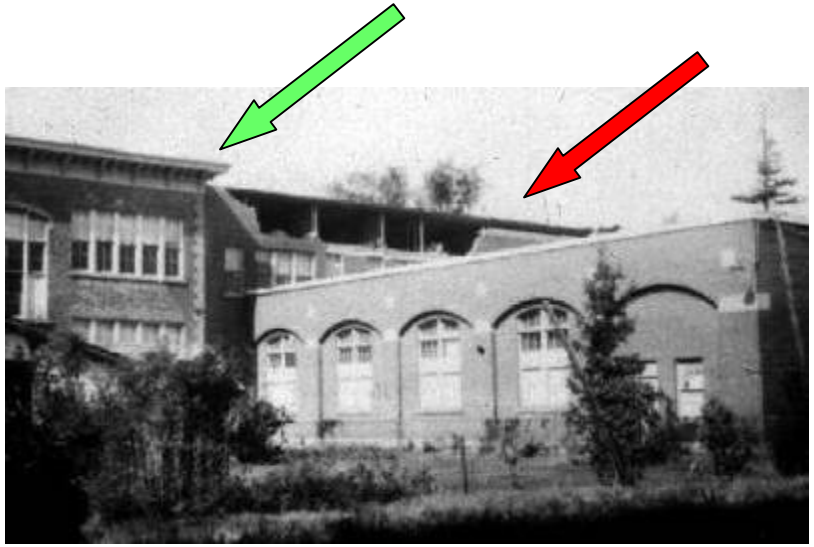

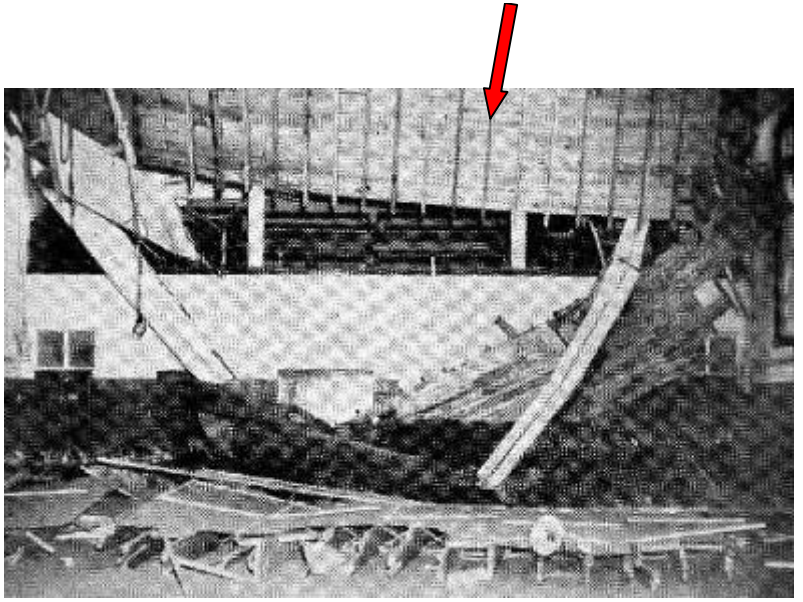

School Gymnasium

# Damage in Cornwall 1944

Houses

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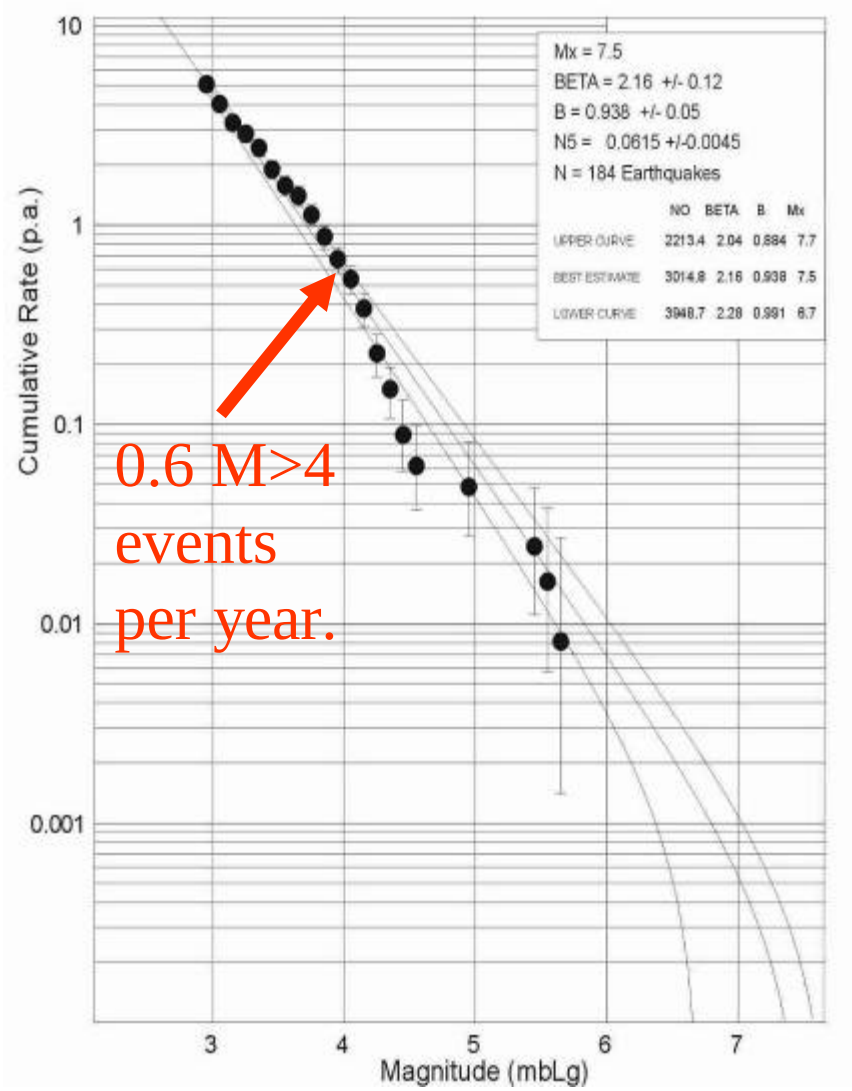
# How often do earthquakes happen near Ottawa?

Magnitude-recurrence for earthquakes within 250 km of Ottawa.

June 23rd was Mw=5.0 (mN=5.6)

Rate about once per 50-70 years

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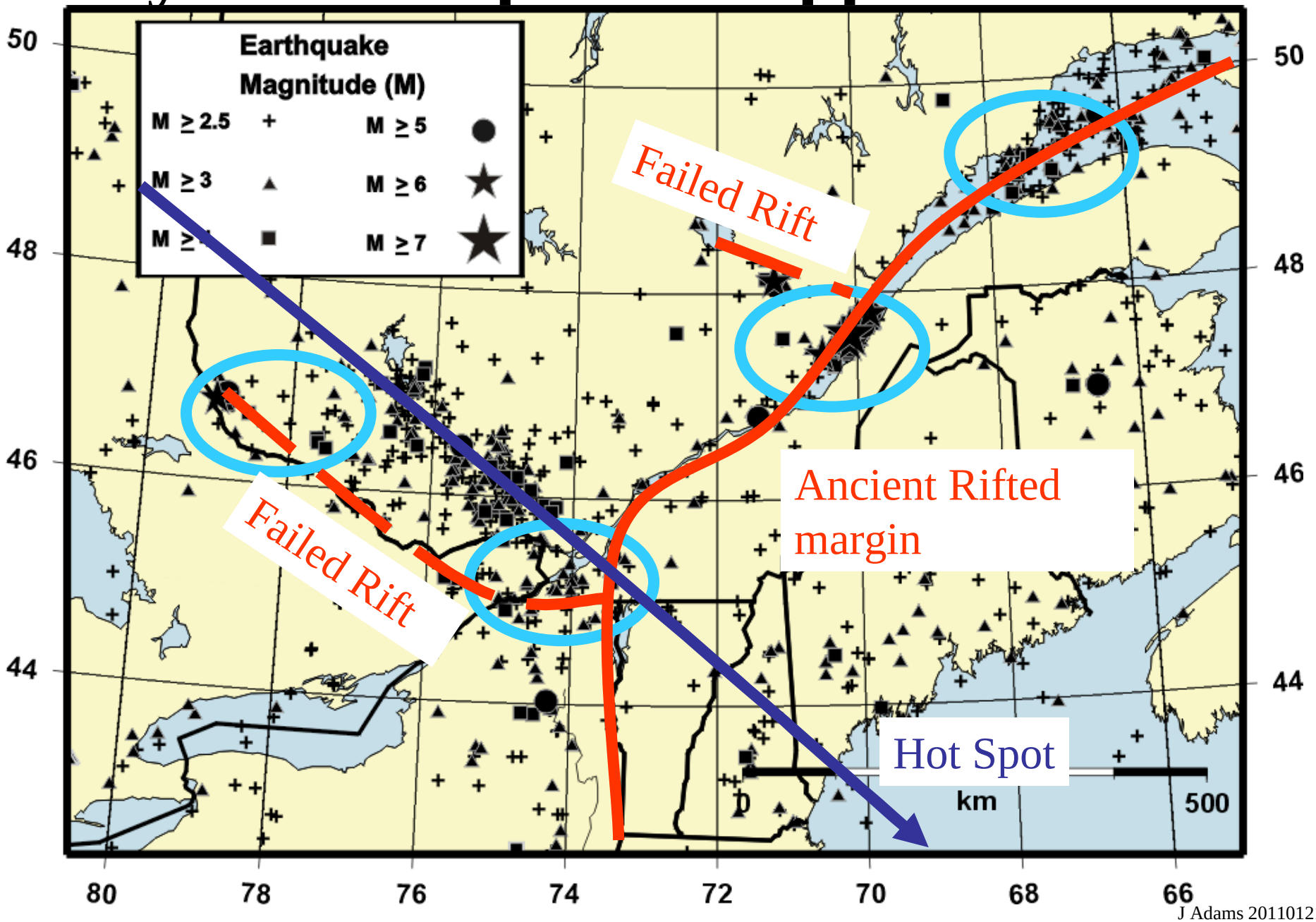
# Why do earthquakes happen here?

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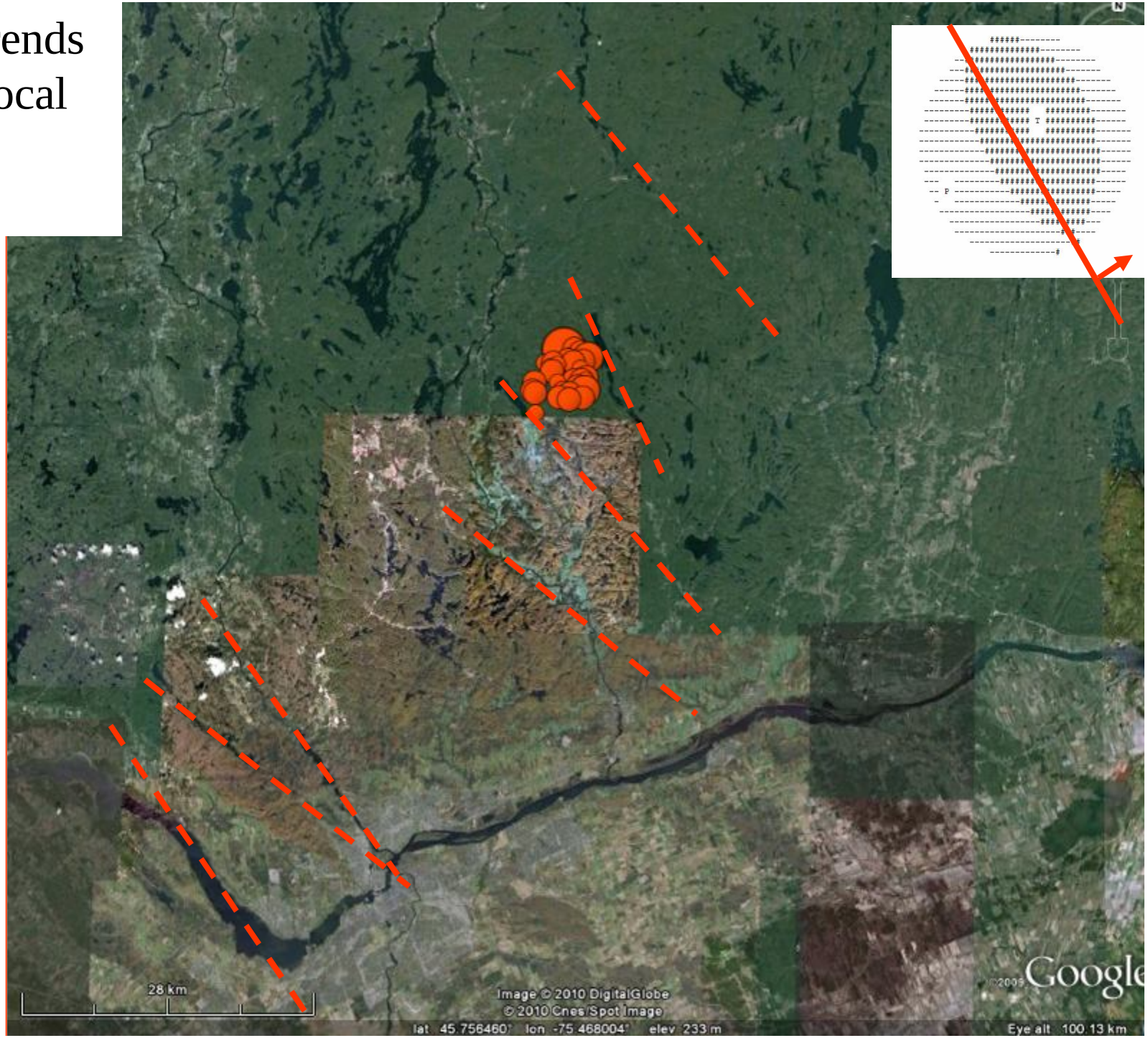
# Structural trends parallel to focal mechanism planes




**Focal mechanism by R Herrmann**

**June 23, 2010 16:01**

Mw = 5.04

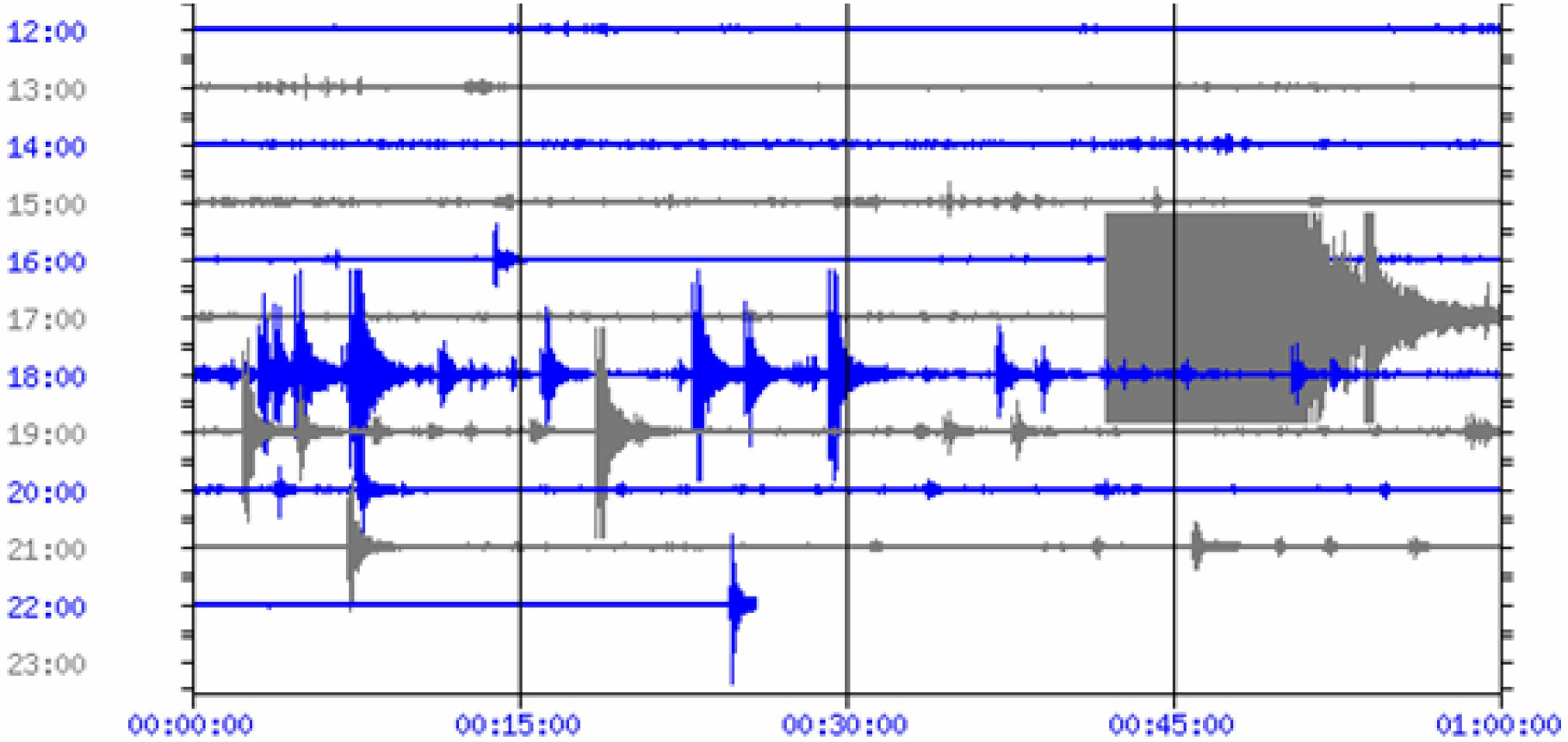
Z = 22 km

Plane Strike Dip Rak

NP1 145 60 80

NP2 344 31 107

# Val-des-Bois earthquake - Aftershocks




NRCan seismometer at Mont-Tremblant captured the main shock and many aftershocks – screen capture Wednesday 23rd at 1833EDT

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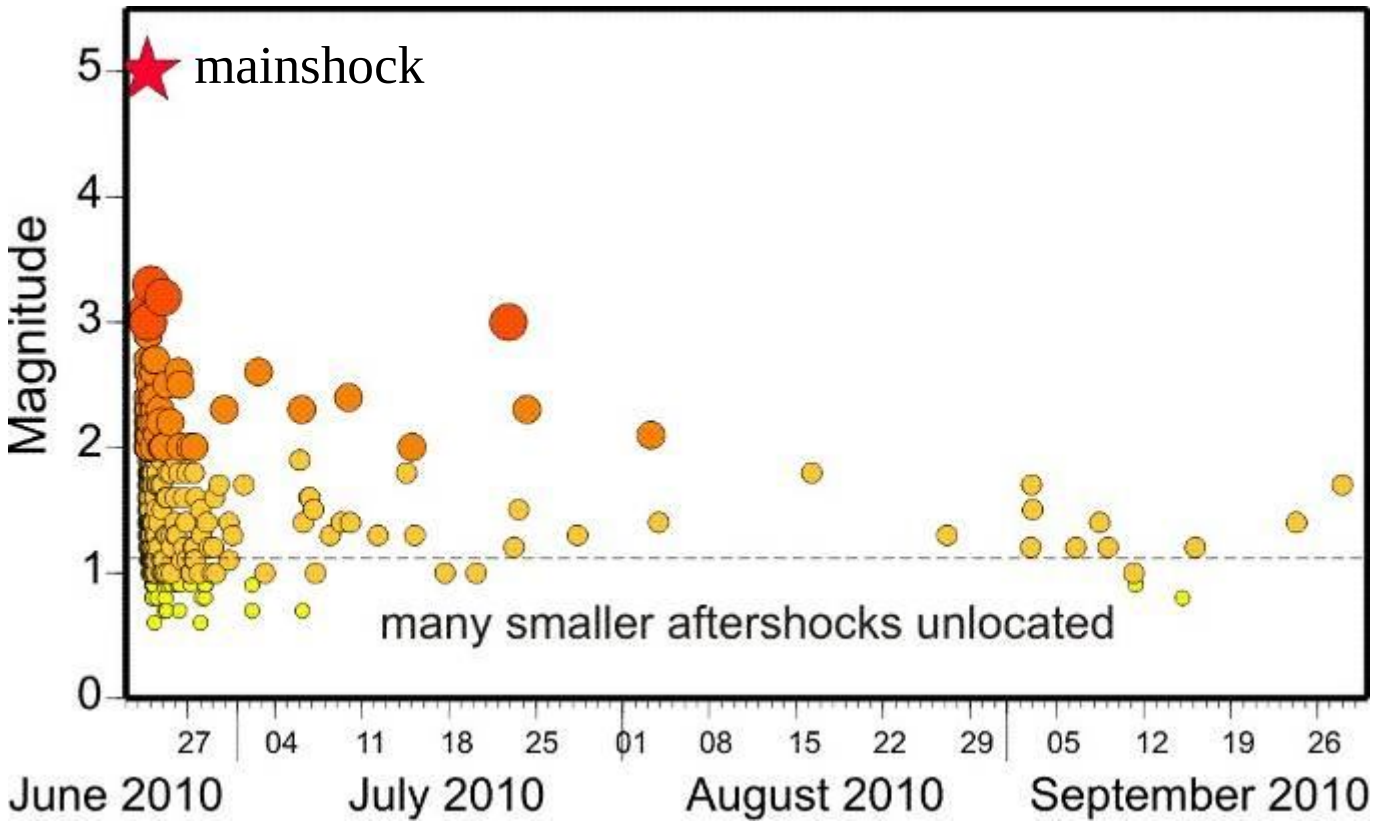


11 aftershocks above magnitude < 2.5 in first 2 hours

Largest aftershock so far at T+6 hours, magnitude 3.3

292 located to date, less than a dozen reported felt

NRCan is continuing to locate aftershocks using permanent network

Field seismographs deployed for the first few weeks will help refine the map distribution

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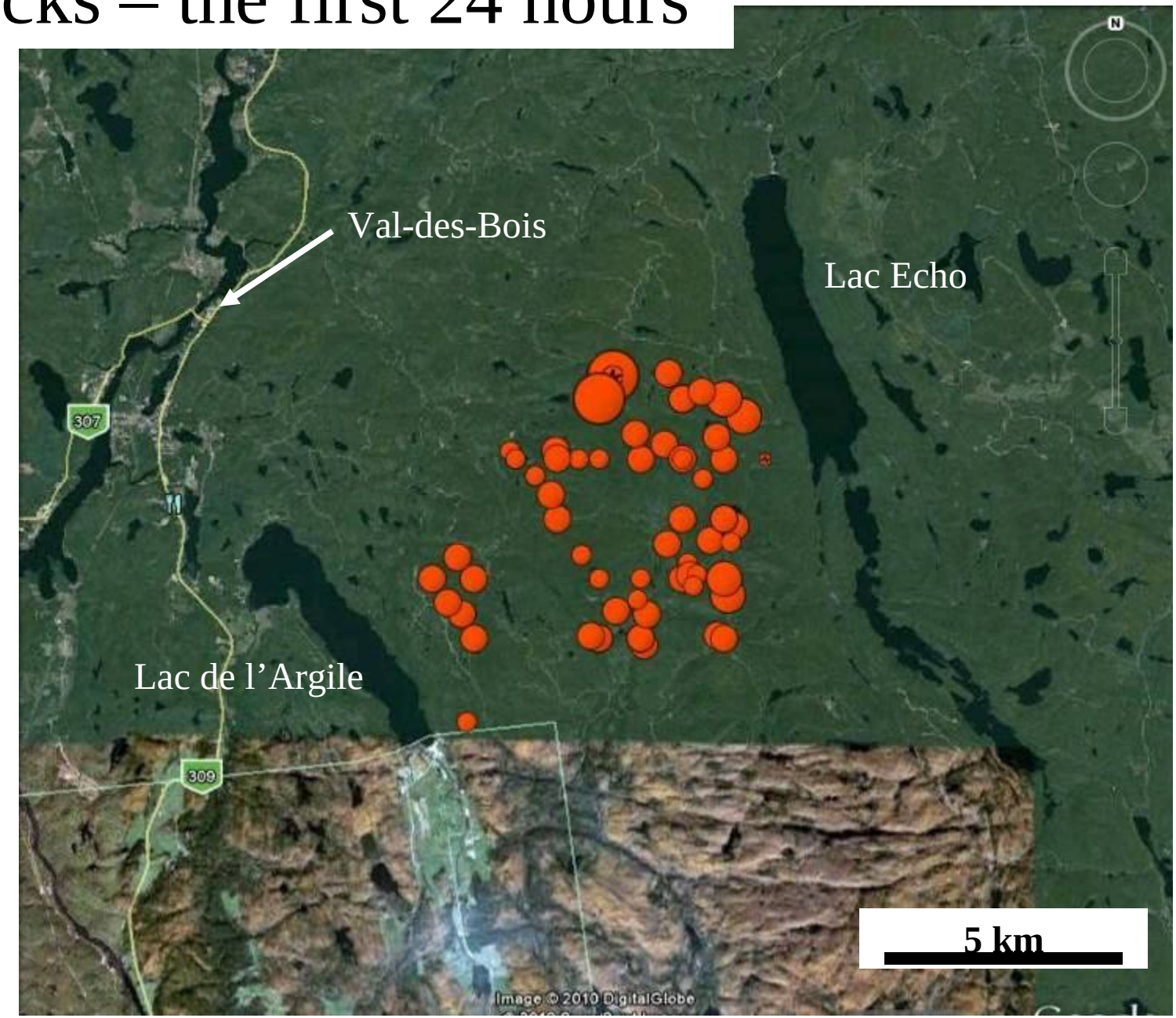
# Aftershocks – the first 24 hours

Field recorders were installed near the earthquakes to refine aftershock locations and depth

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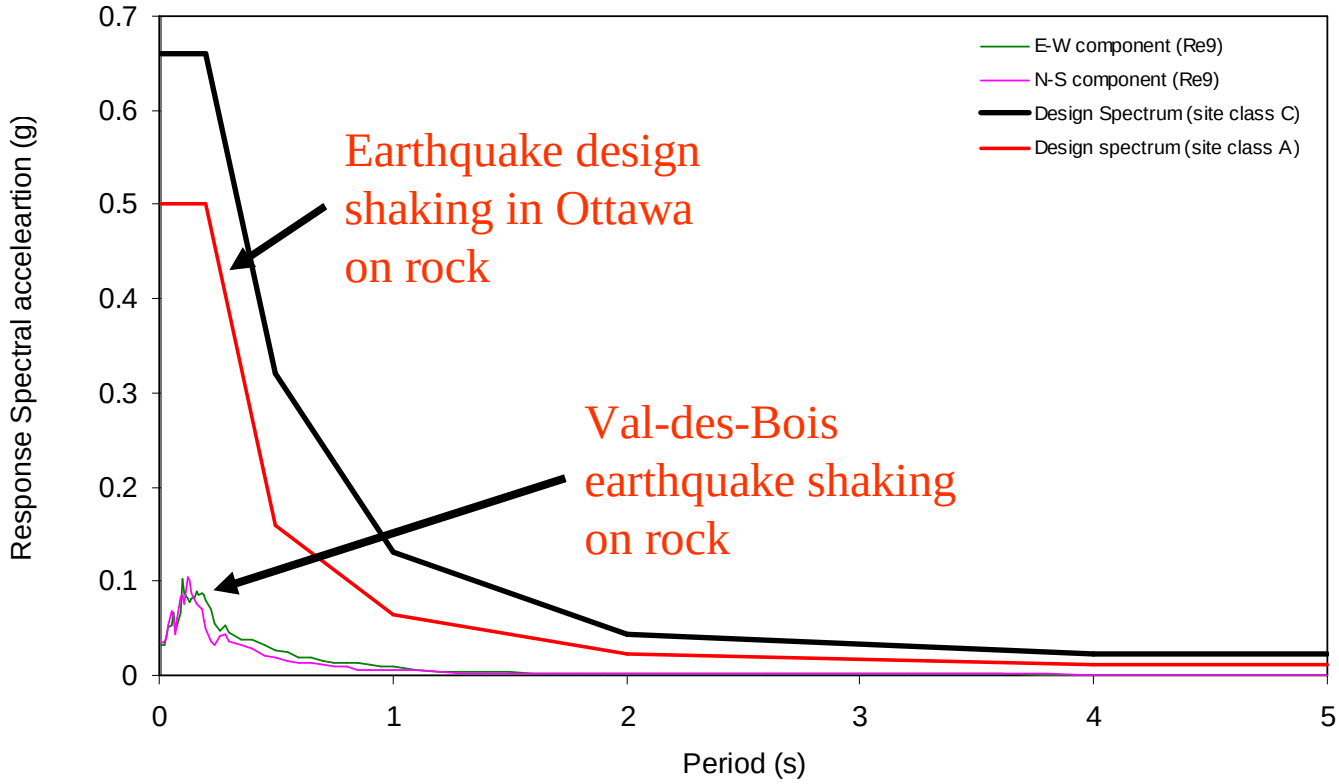
# June 23rd shaking in Ottawa was about

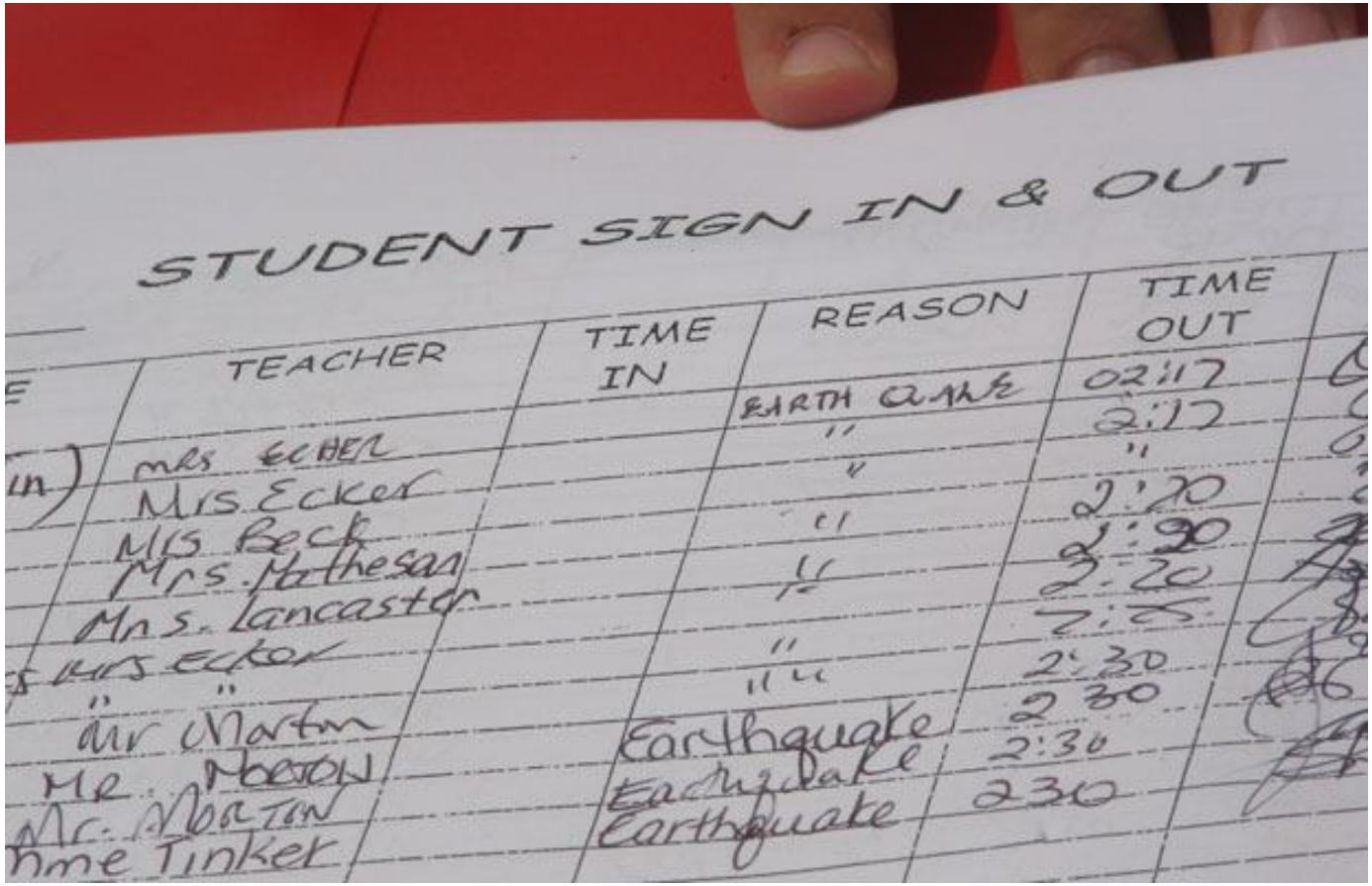
- once-per-150-year level of shaking
- only 1/5th as strong as current building code requires




Shaking recorded at OTT on rock compared with the design spectra for rock and soil at Ottawa, according to National Building Code of Canada 2005

# Examples of June 23rd earthquake effects

Workers unsure what to do …..




**Pictures of Sign Out Sheet at John Young School, Kanata. Grade 6 Graduation ceremonies at John Young were interrupted by the earthquake. Reason for sign out.... EARTHQUAKE Photograph by: Laura Kelland-May,** http://www.ottawacitizen.com/news/earthquake/Reader+Gallery+Ottawa+Earthquake/3191740/story.html#ixzz0rtK2N3JR

## → New safety instructions at Ottawa Catholic school board

- Do not exit a building during an earthquake
- Evacuate only if there are signs of structural damage, fire/smoke, gas leaks or other life-threatening situations
- Avoid use of cell phones

# What should I do?

Wherever you are when an earthquake starts, take cover immediately. Move a few steps to a nearby safe place if need be. Stay there until the shaking stops.

| **DO…** | | **DO NOT…** |
|---|---|---|
| OUTDOORS | INDOORS | |
| Stay outside | Stay inside | Stand in doorways. Doors may slam shut and cause injuries |
| Go to an open area away from buildings, to avoid any falling debris and to leave plenty of room for emergency vehicles and personnel | **Drop** under heavy furniture such as a table, desk, bed or any solid furniture | Stand near windows, bookcases, tall furniture and light fixtures. You could be hurt by shattered glass or heavy objects |
| If you are in a crowded public place, take cover where you won't be trampled | **Cover** your head and torso to prevent being hit by falling objects | Take elevators. If you are in an elevator during an earthquake, hit the button for every floor and get out as soon as you can |
| Stay away from overhead power lines and severed/dangling electrical wires | **Hold** onto the object that you are under so that you remain covered | Stand near downed power lines – stay at least 10 meters away to avoid injury |
| | Stay away from windows, skylights, large overhead light fixtures, and shelves with heavy objects | Stay near a coastline. Earthquakes can trigger large ocean waves called tsunamis |
| | If you are in a wheelchair, lock the wheels and protect the back of your head and neck | |
| | If you are at work, you should wait for instructions from your building emergency organization personnel before exiting. The integrity of exit stairwells and the outside of the building should be confirmed before any building evacuation is ordered. A building evacuation can be dangerous because of potential falling debris. | |

http://www.getprepared.gc.ca/knw/ris/eq-eng.aspx#a4

Val-des-Bois

Minor damage
to chimneys
and contents

Embankment failure south of Bowman

**Embankment failure south of Bowman, Quebec.  Photograph by: Jean Levac, The Ottawa Citizen.**
http://www.montrealgazette.com/news/canada/Fossil+faults+blame+central+Canada+quake/3192946/story.html#ixzz0rirwWmpz

# Landslides

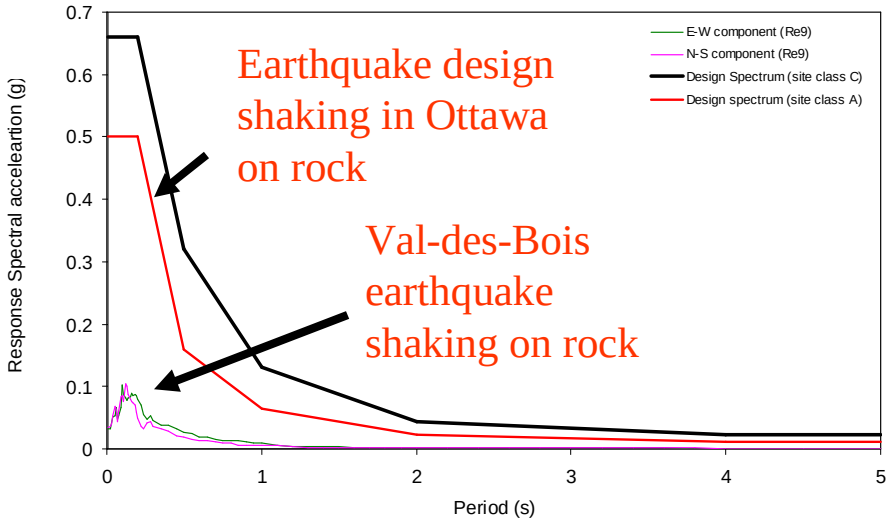
Chemin Binette

11 km from epicentre

Happened the next day


Greg Brooks photomosaic

# Val-des-Bois conclusion…..



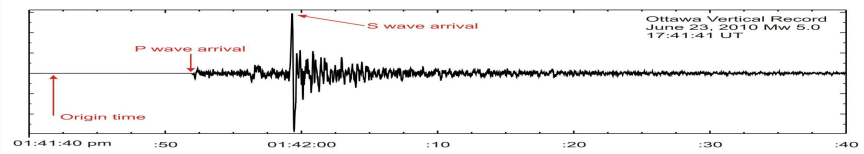

Shaking much less than the seismic design levels

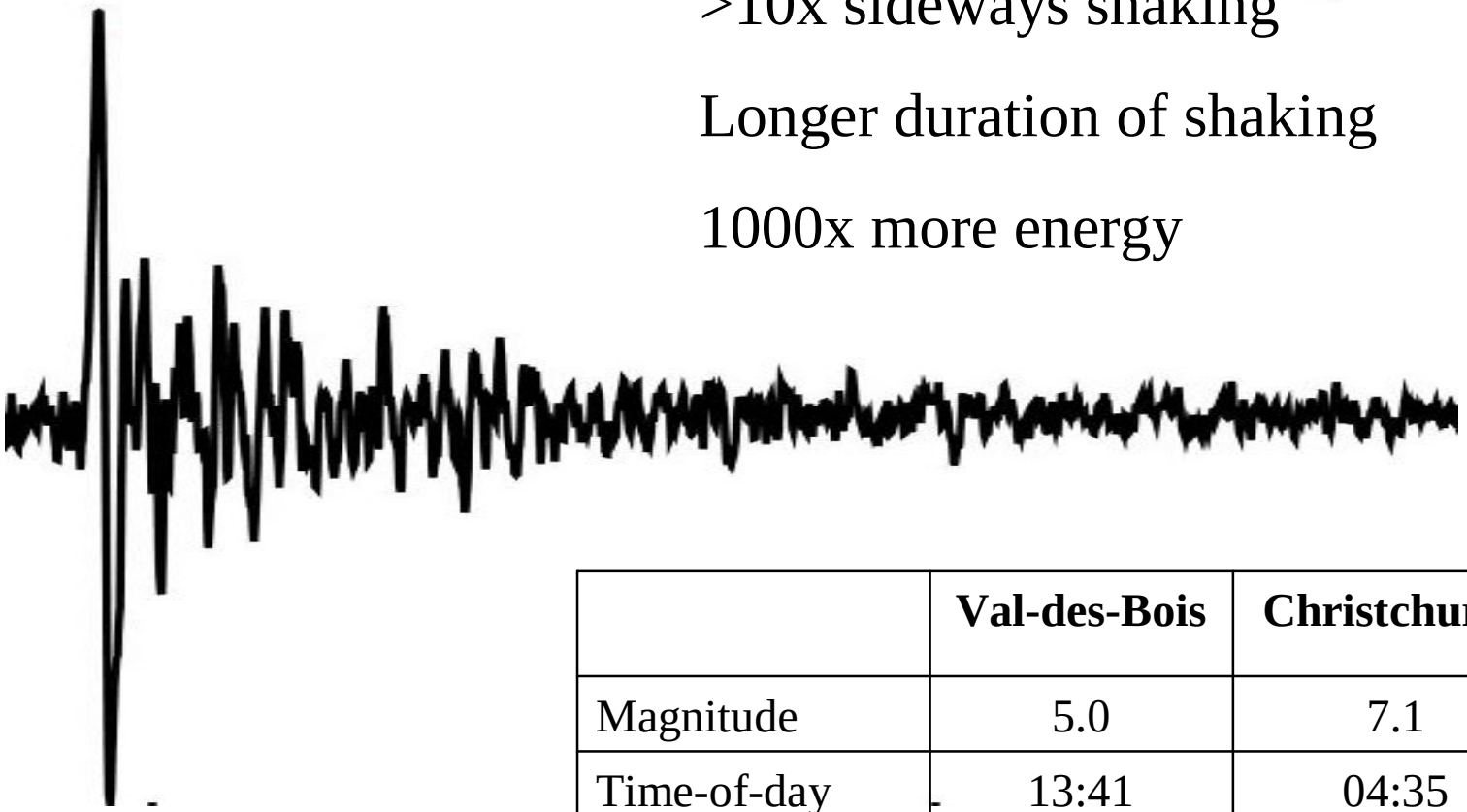
A relatively uncommon level of earthquake shaking

Minor damage

A wake-up call to

- Improve hazard assessment
- Improve risk assessment
- Improve emergency management



>10x sideways shaking

Longer duration of shaking

1000x more energy

| | **Val-des-Bois** | **Christchurch** |
|---|---|---|
| Magnitude | 5.0 | 7.1 |
| Time-of-day | 13:41 | 04:35 |
| Season | Summer | Spring |
| Distance to city | 60 km | 40 km |

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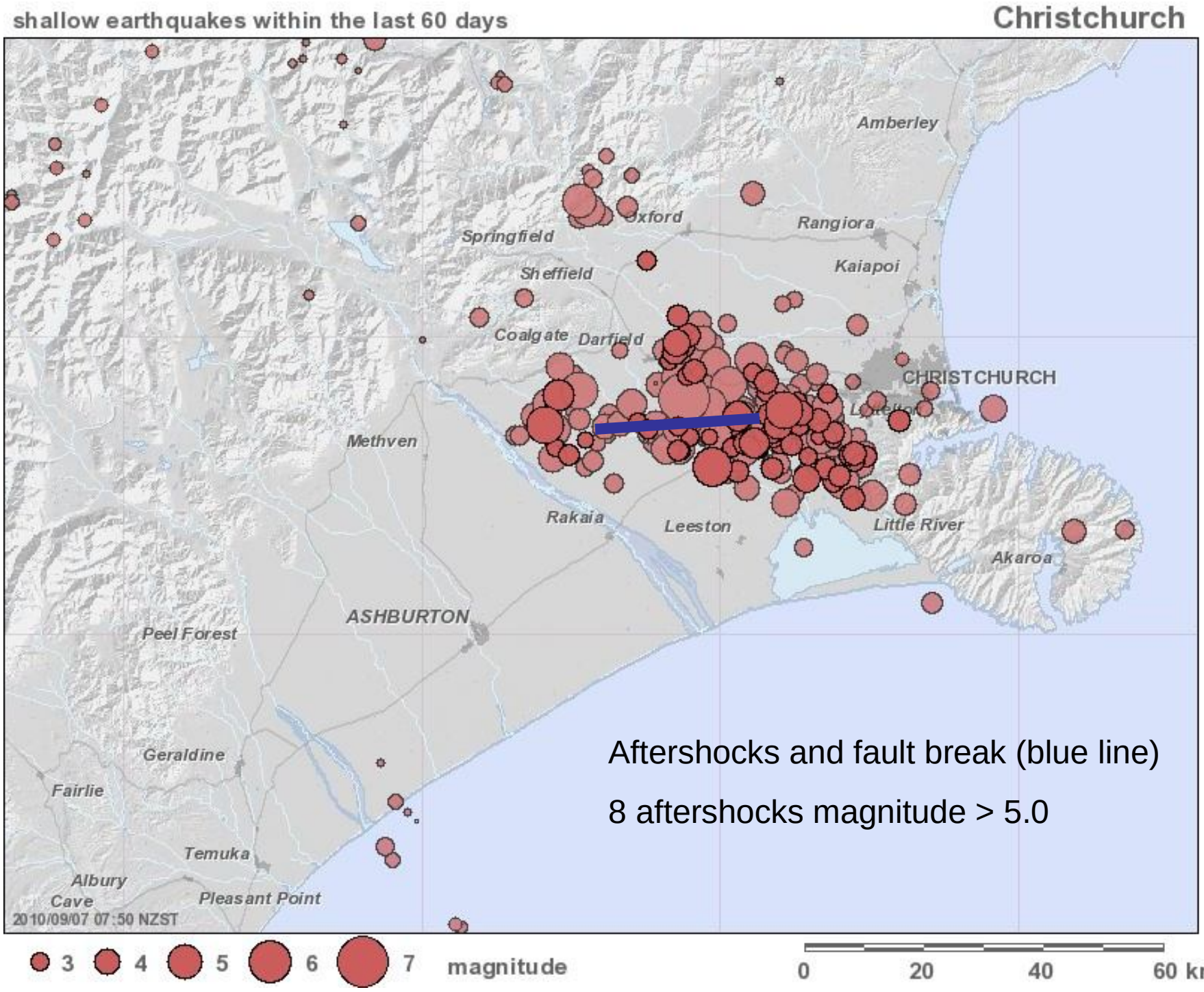
# Darfield Earthquake 2010
# Near Christchurch
# New Zealand

Saturday, September 4 at **4:36 am**,
Magnitude 7.1
shallow with surface rupture
40 km from Christchurch (pop 330,000)

- No deaths (most people at sleep in their wooden houses)
- 100,000 homes damaged (out of 160,000)
- More than 500 buildings badly damaged
- 90 buildings may need to be demolished.
- Additional damage in aftershocks
- Demolition underway – how to preserving historic bldgs?
- Losses circa $US4B
- Expect 100,000+ insurance claims


shallow earthquakes within the last 60 days
Christchurch
Amberley
Oxford
Springfield
Rangiora
Sheffield
Kaiapoi
Coalgate
Darfield
CHRISTCHURCH
Methven
Rakaia
Leeston
Little River
Akaroa
ASHBURTON
Peel Forest
Geraldine
Fairlie
Temuka
Albury
Cave
Pleasant Point
2010/09/07 07:50 NZST
Aftershocks and fault break (blue line)
8 aftershocks magnitude > 5.0
3
4
5
6
7
magnitude
0
20
40
60 km

Surface fault break 22 km long

- offsets roads, fences, tracks and irrigation channels
- sideways offset about 3 m
- vertical offset <1 m

# Masonry damage

Christchurch 2010



# Vehicle damage

## Christchurch 2010

# Earthquake damage

Christchurch 2010



## http://www.earthquakecommission.blogspot.com/ on 20110113

So, just like the other 900 new staff, I've had to learn a lot of things quickly –

Again, I have been struck by the enormity of the task ahead. Here the main office consists of 3 floors, packed full of people doing different tasks, including those managing the assessment teams, claims administrators and the claims filing team. The filing room has so many files that if they were placed end to end they would reach as far as 55 kilometres

It's in Christchurch where we are running our pre-established training programme for new assessors. Following the earthquake, we realised quite quickly that we were going to exhaust the available pool of practising assessors in New Zealand (and Australia) needed for the massive task ahead.

We have now received over 167,000 claims, have contacted 40% of claimants and are on target to meet the deadline set for completing all claims of less than $10,000 by the 28th February and all assessments by the end of March

(T+6 months)

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# Current estimates for Darfield NZ earthquake losses and insurance

Deaths: 0; injuries: 2 major, 100 slight

Homeless 4000 (1200 uninhabitable houses)

Economic loss  $US5B (range 3.8-6)

- Loss ~5% of GDP
- compare Haiti 2010 70-120%; Chile 2010 11-15%

Insured $US3.9B (range 3.0-5.5)

- NZEQComm = $1.15B, then reinsurance
- Compare Haiti $US 0.03-0.15B

# An interesting ranking of comparative earthquake losses 1900-2010

James Daniell compiles the CATDAT Damaging Earthquakes Database

Report "2010 – the year in review" CEDIM Earthquake Loss Estimation Series Research Report 2011-01 available through www.cedim.de

***Table 6 – List of highest insured losses (1900-2010) in 2010 Country CPI adjusted $ international***

| Rank | Earthquake | Country | Date | Insured Loss Range | Pref. Source for Event Loss |
|---|---|---|---|---|---|
| 1 | Northridge | USA | 17.01.1994 | $22.919bn | RMS |
| 2 | Great Kanto | Japan | 01.09.1923 | $8.728bn-$15.06bn | Daniell (2010b) |
| **3** | **Maule** | **Chile** | **27.02.2010** | **$7.566bn-$12.00bn** | **Standard and Poor's** |
| 4 | Kobe | Japan | 16.01.1995 | $6.78bn | Horwich (2000), RMS |
| =5 | San Francisco | USA | 18.04.1906 | $5.983bn | Daniell (2008-2010a) |
| **=5** | **Darfield** | **NZ** | **03.09.2010** | **$3.04bn-$5.5bn** | **PartnerRe, Catlin** |
| =5 | Izmit | Turkey | 17.08.1999 | $3.381bn-$7.889bn | RMS (1999) |
| 8 | Sumatra | Many | 26.12.2004 | ***$2.311bn-$4.113bn*** | Average CPI used |
| 9 | Loma Prieta | USA | 18.10.1989 | $2.506bn | Amer. Ins. Serv. Group |
| 10 | Newcastle | Australia | 27.12.1989 | $2.046bn | Daniell (2010b) |

We'll mention this one again, later

Equivalent masonry buildings in Ottawa

James Street, built 1892

Byward Market

# So how to mitigate Canada's next earthquake disaster?

We need building codes because we

Can't predict earthquakes

- May never be able to (chaotic process?)
- Or predicted/unpredicted rate may be too small

Can "sort-of" forecast earthquakes

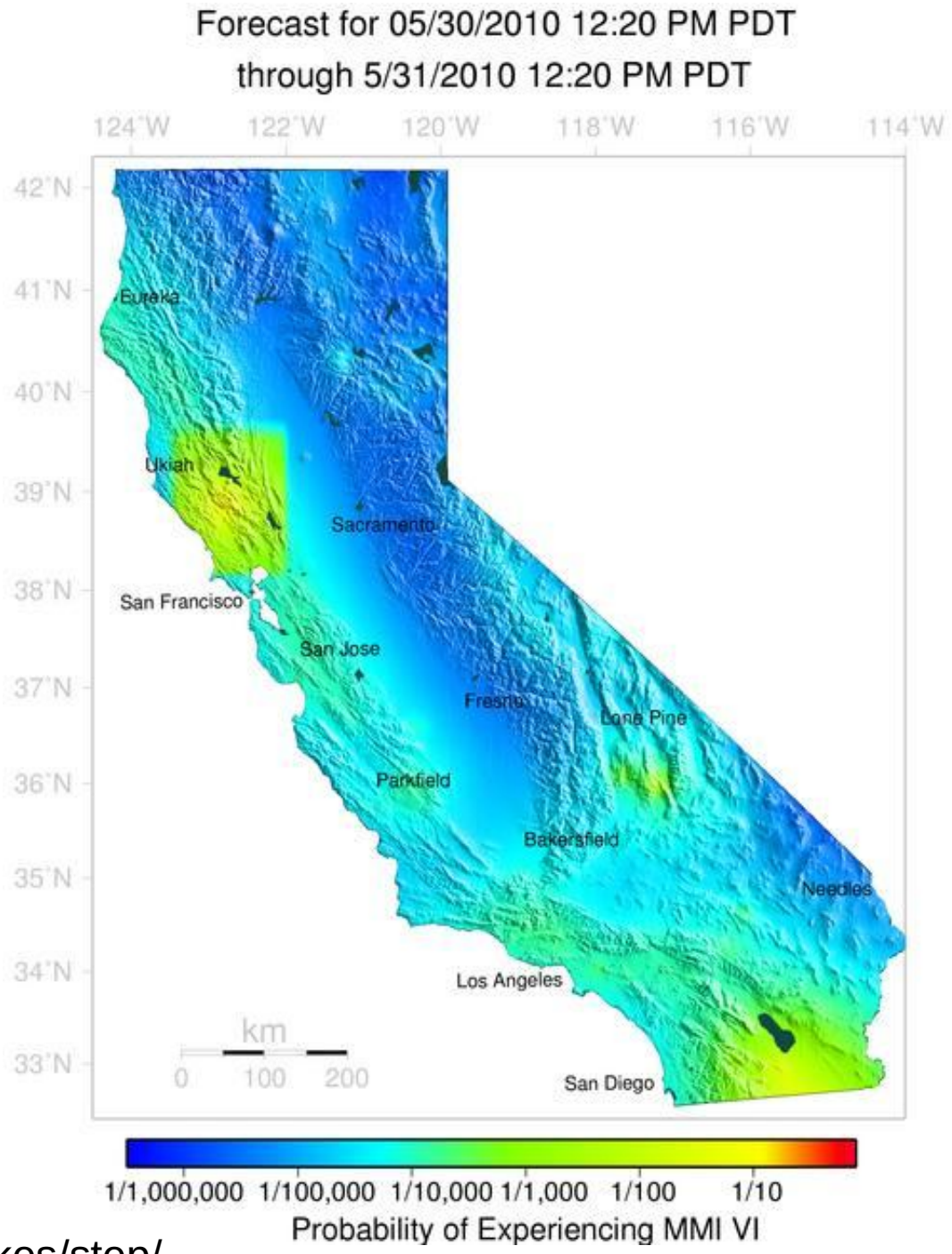
- Seismic hazard maps are long-range forecasts
  - "2% chance in 50 years that shaking exceeding X will occur"
- In some places we can make time-dependent forecasts "probability in the next 5 years is 4% and for the following 5 years 6.5%"
- Short-term forecasts …….

In California scientists make forecasts for the next day

The background probabilities are between 1 in 10,000 and 1 in 100,000, but rise to about 1 in 100 after a M4 event*

We don't approach "80% of rain in next 24 hours"

* the risk is greater than your chance of a car accident for ~1 day, but not much more




http://earthquake.usgs.gov/earthquakes/step/

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# Even if we had valid forecasts…….

It's not clear how we should react to a valid forecast anyway

"80% chance of rain in next 24 hours" → take umbrella

"20% chance of rain in next 24 hours" → hold BBQ

"1% chance of strong earthquake shaking" → ????!????!

Ignore (but I'm worried!)

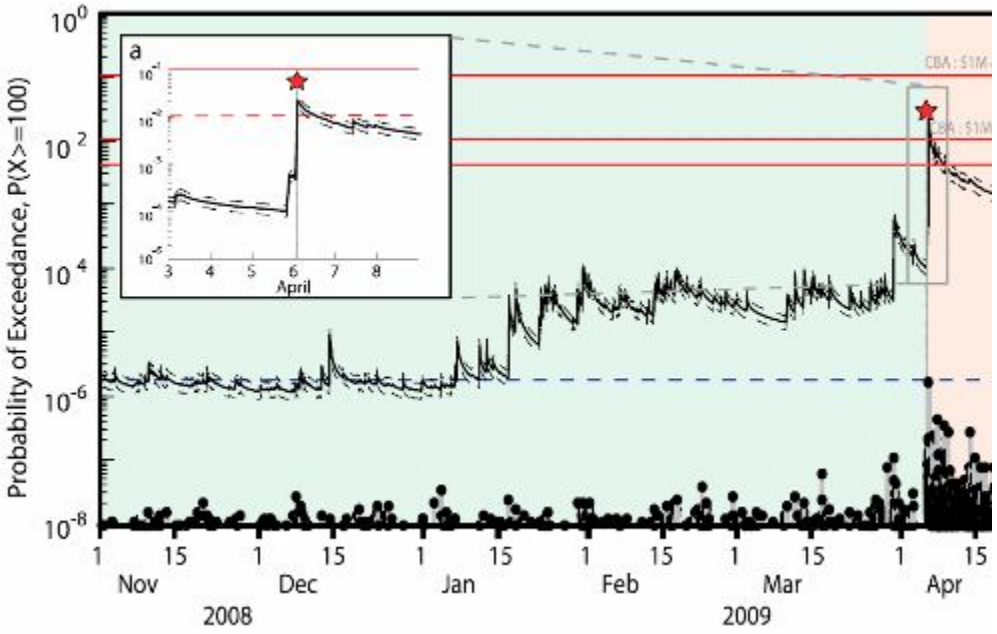
Tent in the backyard (but there's an 80% chance of rain!)

??? (we'll come back to this, later)

Possible exception is immediately after a strong earthquake
protection from aftershocks and larger mainshocks

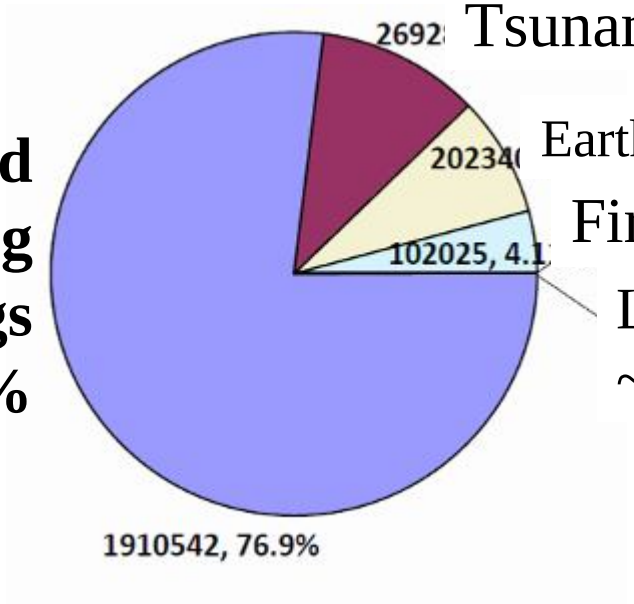
*It was a widely accepted practice in Italy in the 17th century to remain outside of buildings for two days after a moderate to strong earthquake, in order to avoid casualties due to subsequent events* [Boscarelli, 1992].

L'Aquila earthquake (2009, magnitude 6.3, Italy, 299 killed) was preceded by foreshock activity implying a 4-order-of magnitude increase in the probable rate of dying, yet a general evacuation was not cost-effective in the period immediately before the earthquake (van Stiphout et al. GRL 2010).



**Since we can't forecast in a very useful way (yet!), what can we do?**

Most deaths in earthquakes are from




**People killed in collapsing buildings 77%**

Tsunamis 11%

Earthquake-triggered landslides 8%

Fire 4%

Liquefaction; heart attacks ~1%

2.6M fatalities, 1900-2010
Source: Daniell 2011, Figure 10

We <u>can</u> do something about collapsing buildings, through our National Building Code

# National Building Code of Canada


- For common buildings, not critical facilities
- National Building code is “model code”
- Must be adopted by each Province (legal)
- Followed by professionalism of engineers
- Regulated (+/-) by municipalities

Avoidance is not a systemic problem

# Objectives of the NBCC

1. to protect the life and safety of building occupants and the general public as the building responds to strong ground shaking,

2. to limit building damage during low to moderate levels of ground shaking, and

3. to ensure that post-disaster buildings* can continue to be occupied and functional following strong ground shaking, though minimal damage can be expected in such buildings.

*Hospitals, police stations, prisons, water & sewage treatment …

For New buildings only
Existing buildings can pose a significant risk, but retrofit is difficult/expensive

# NBCC has two main parts

## Part 4

- Exceeding 600 $m^2$ or exceeding 3 storeys
- Major occupancies
- Post-disaster buildings

## Part 9

- Small Buildings – no explicit *seismic* design requirements
- Lateral loads from earthquakes dealt with implicitly
- Standard design for load bearing OK for earthquake

1960s wood frame bungalow

**Experience is that wood-frame houses provide good life safety (but large $$ losses)**

1980s wood frame 2-storey with brick veneer

# Earthquakes are rare events

What is the right design value?

How rare an event should we consider?

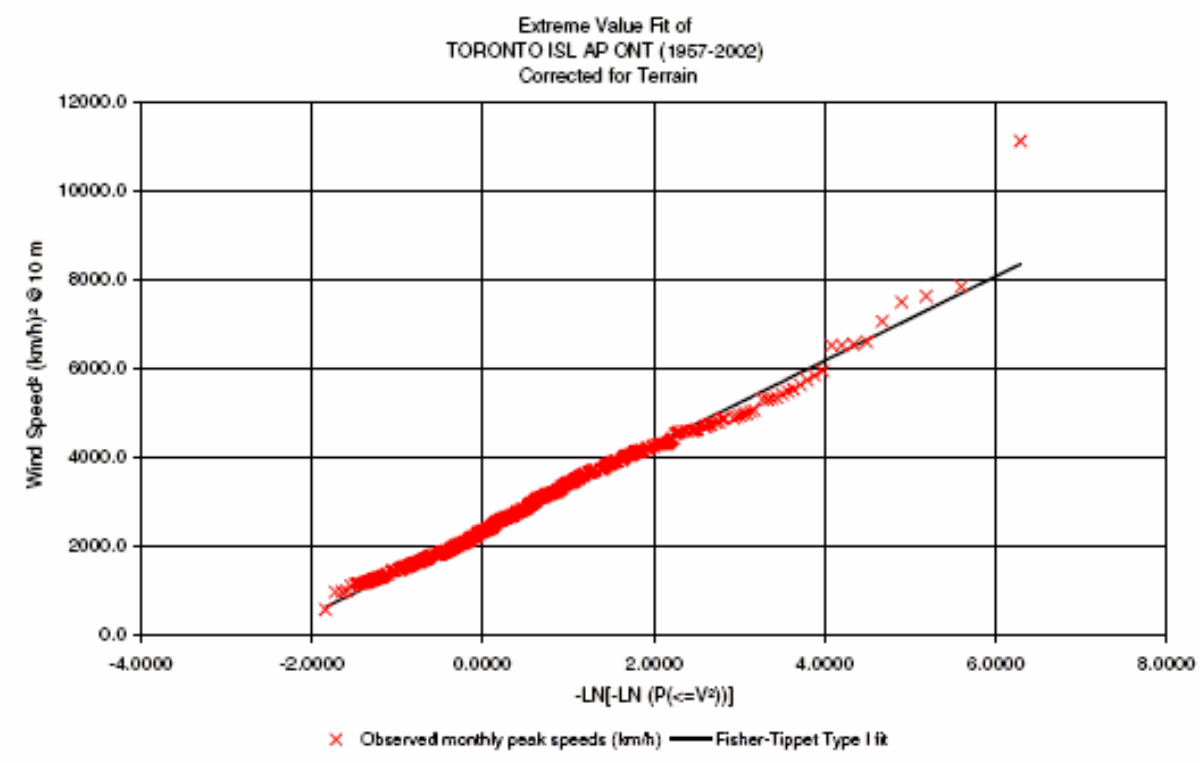
NBCC wind  p=0.02 p.a.

(2% chance of being exceeded in a given year)

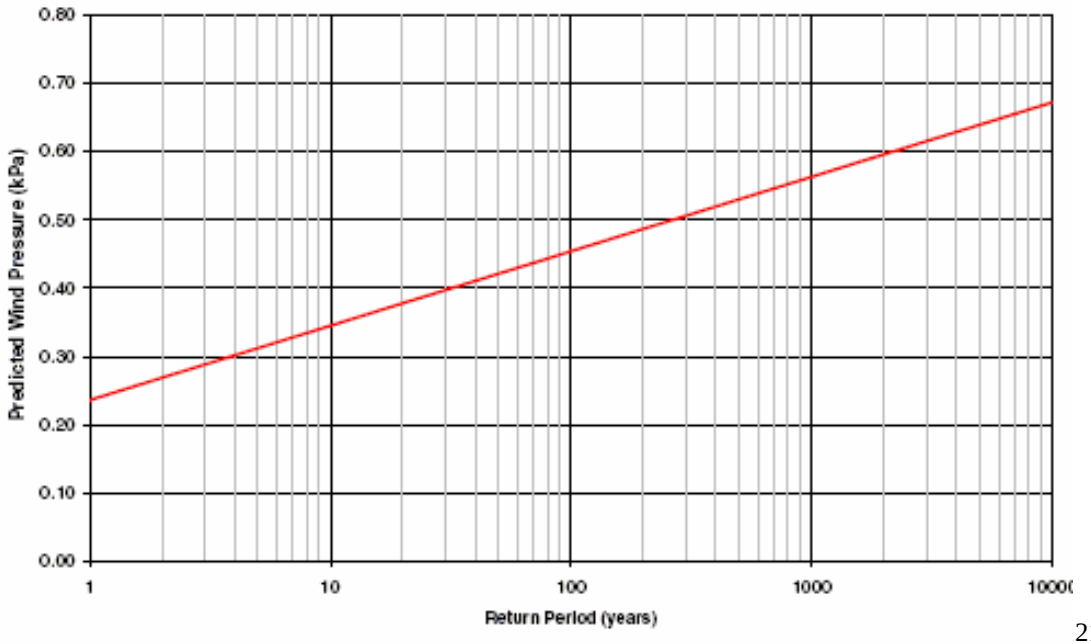
NBCC earthquake p=0.000404 p.a.

(2% chance of being exceeded in 50 years )

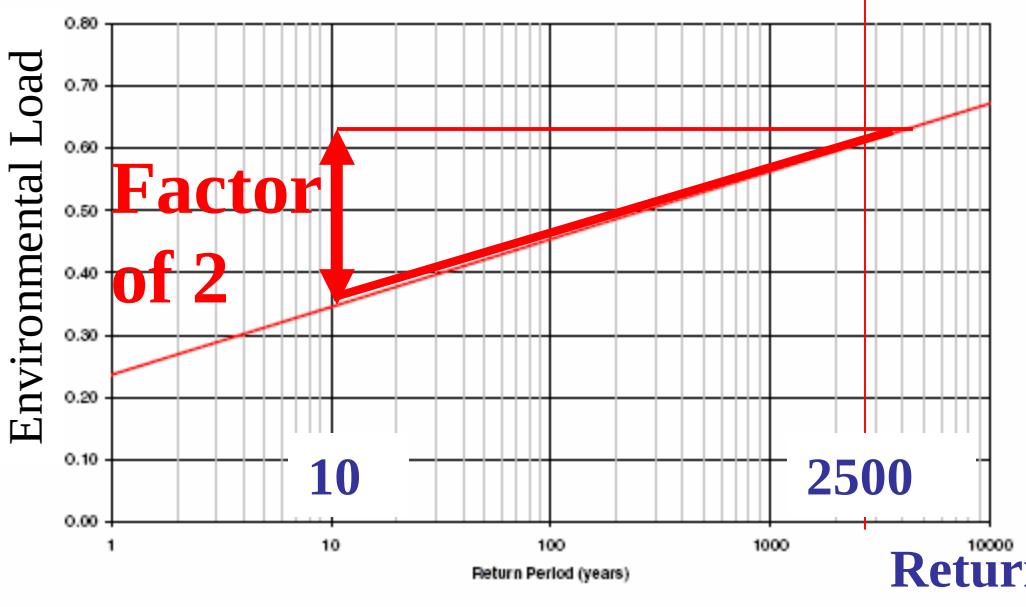
1/50$^{th}$ the probability – why?!



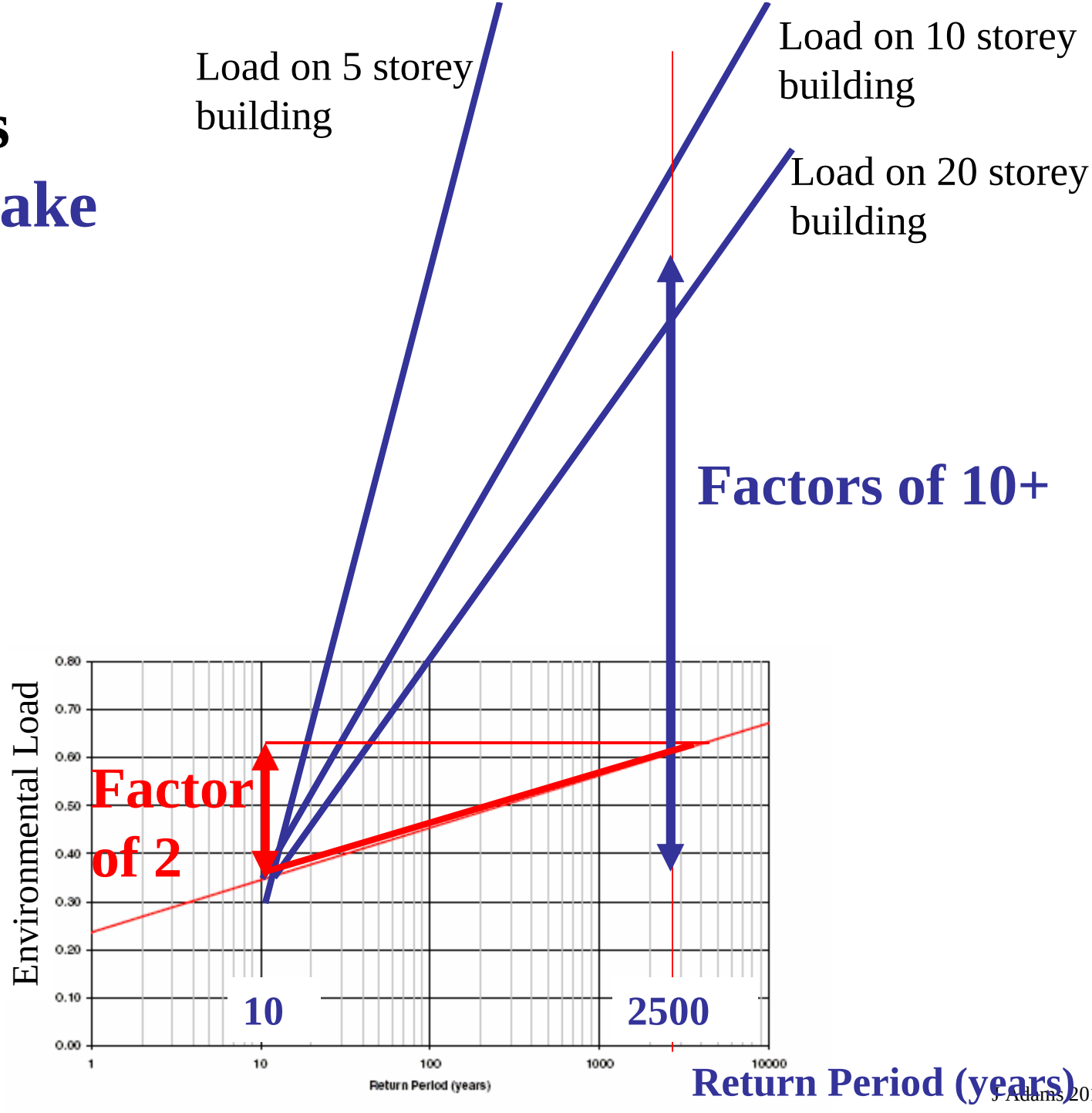

# Toronto Wind Loads



# Wind


Environmental Load
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1
10
100
1000
10000
Return Period (years)
Factor
of 2
10
2500
Return Period (years)

# Wind vs Earthquake



So we have a class of hazards (winds, waves, ….)

Where a relatively short recording period can give good feeling for the largest event we need to design for

Where individual experience (+parents +grandparents) gives a good basis for individual gut understanding

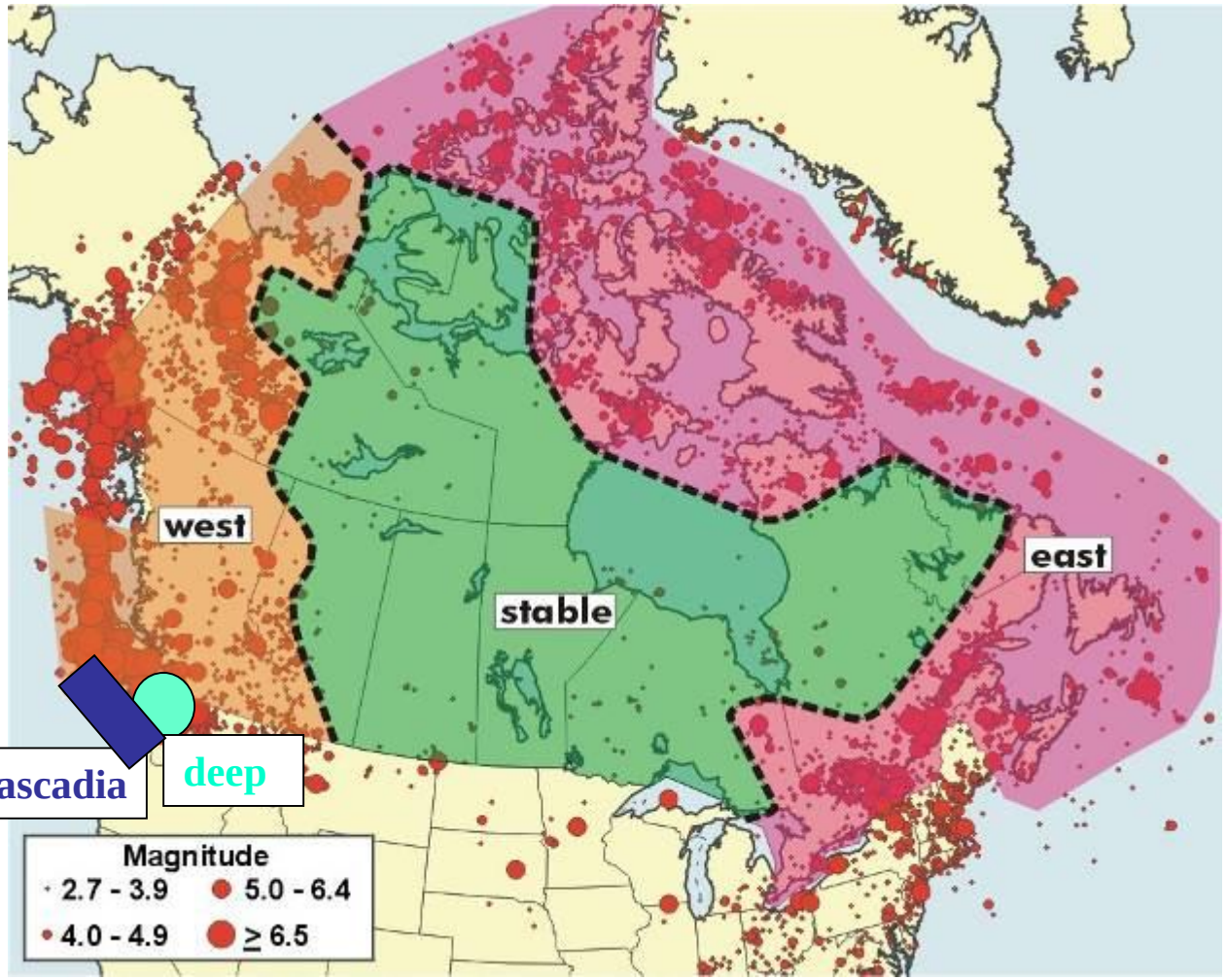
And another class of hazards – earthquakes – where an individual's experience and even written history don't give us much guidance for the important events

What to do?

We need to create mathematical models to make the low probability estimates

# Modeling Seismic Hazard in Canada

**Main elements of the 4th Generation model**




M9

~Sumatra 2004

# Probabilistic seismic hazard

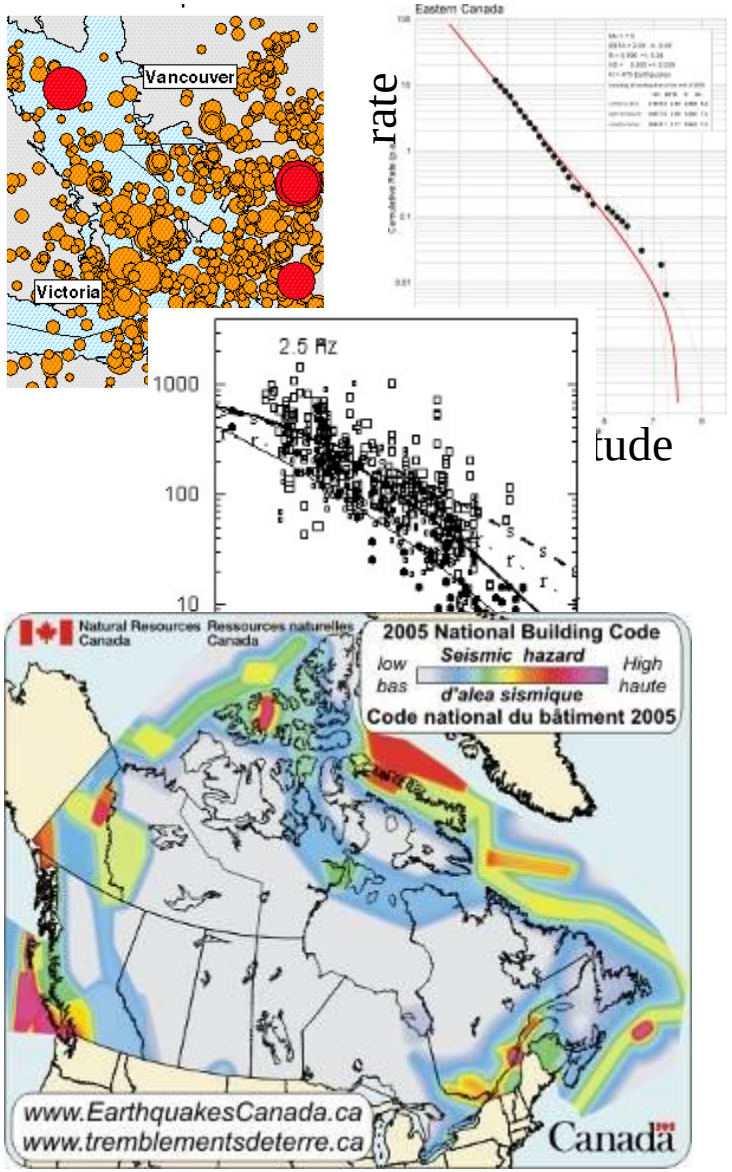
Earthquake Catalog

Earthquake locations

Earthquake number - sizes - rates

Shaking vs distance relations

**Seismic hazard**

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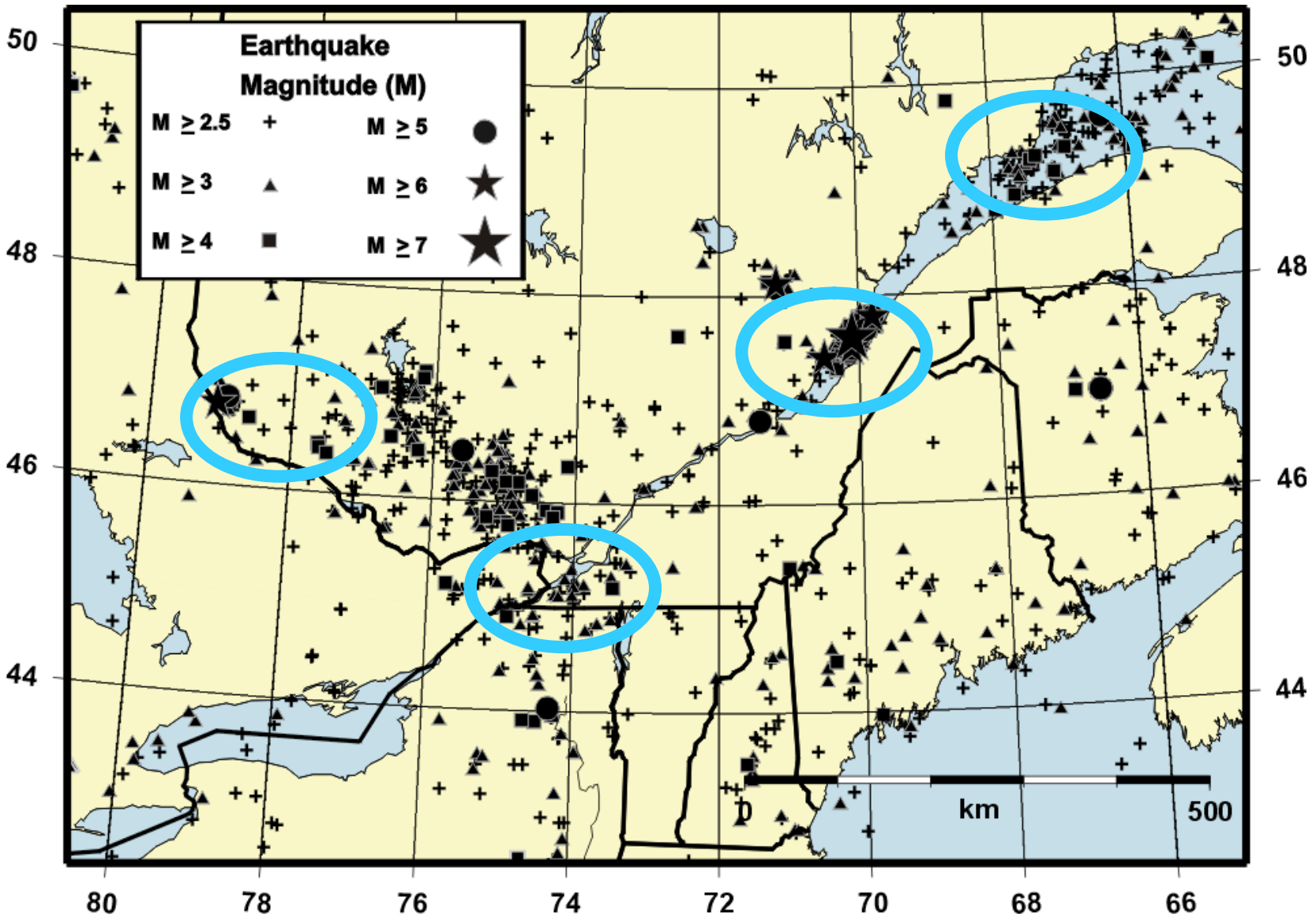


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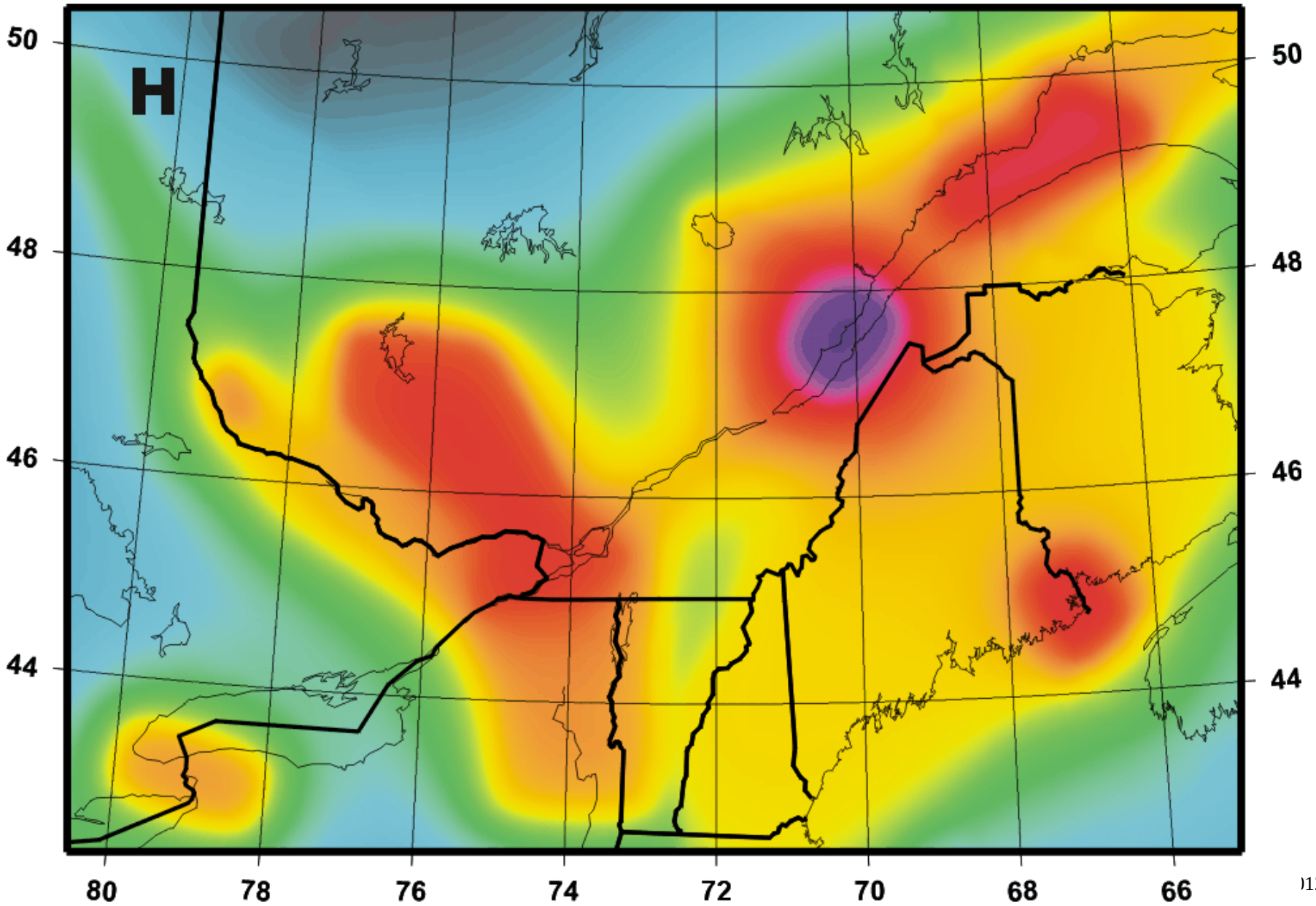
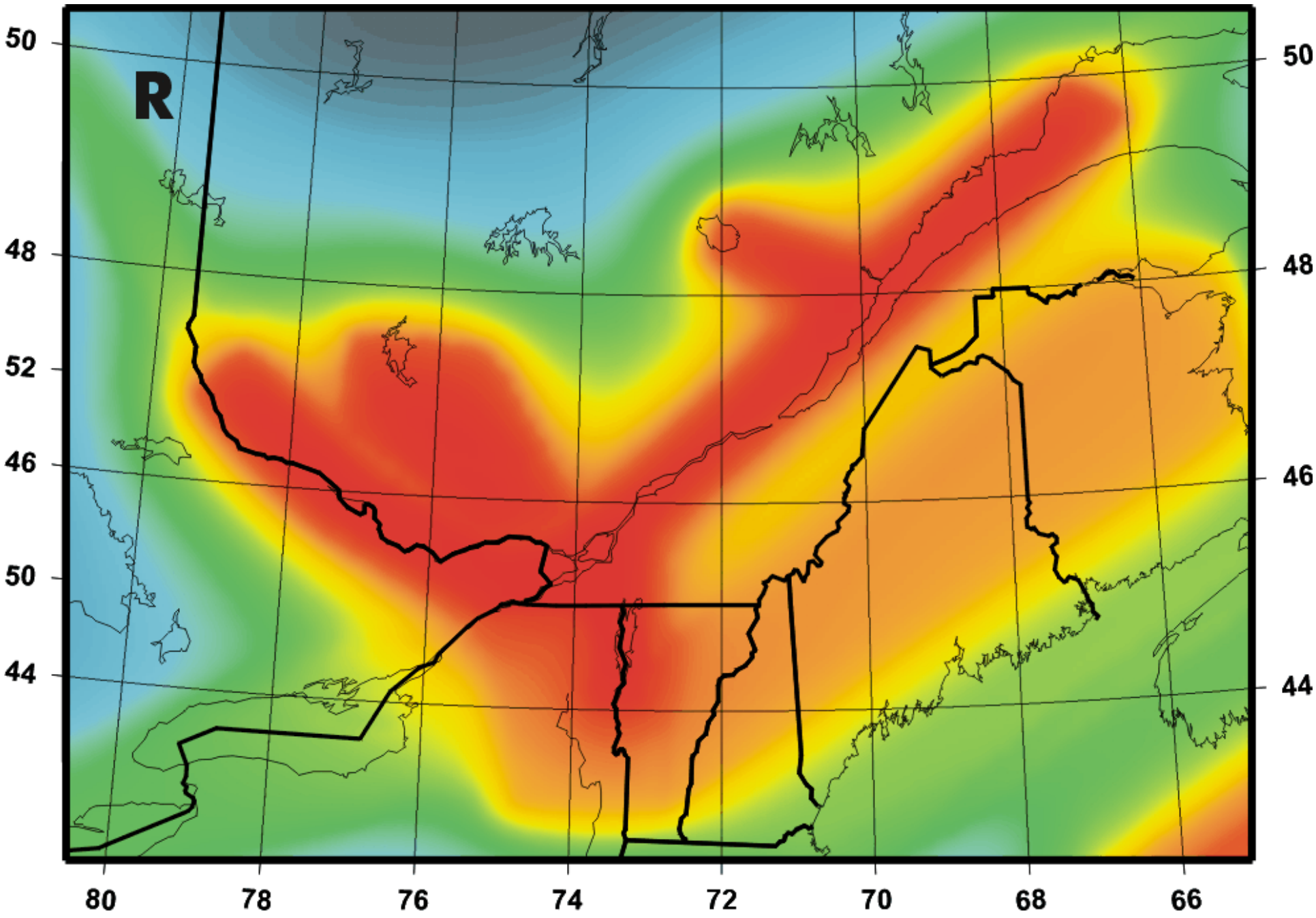
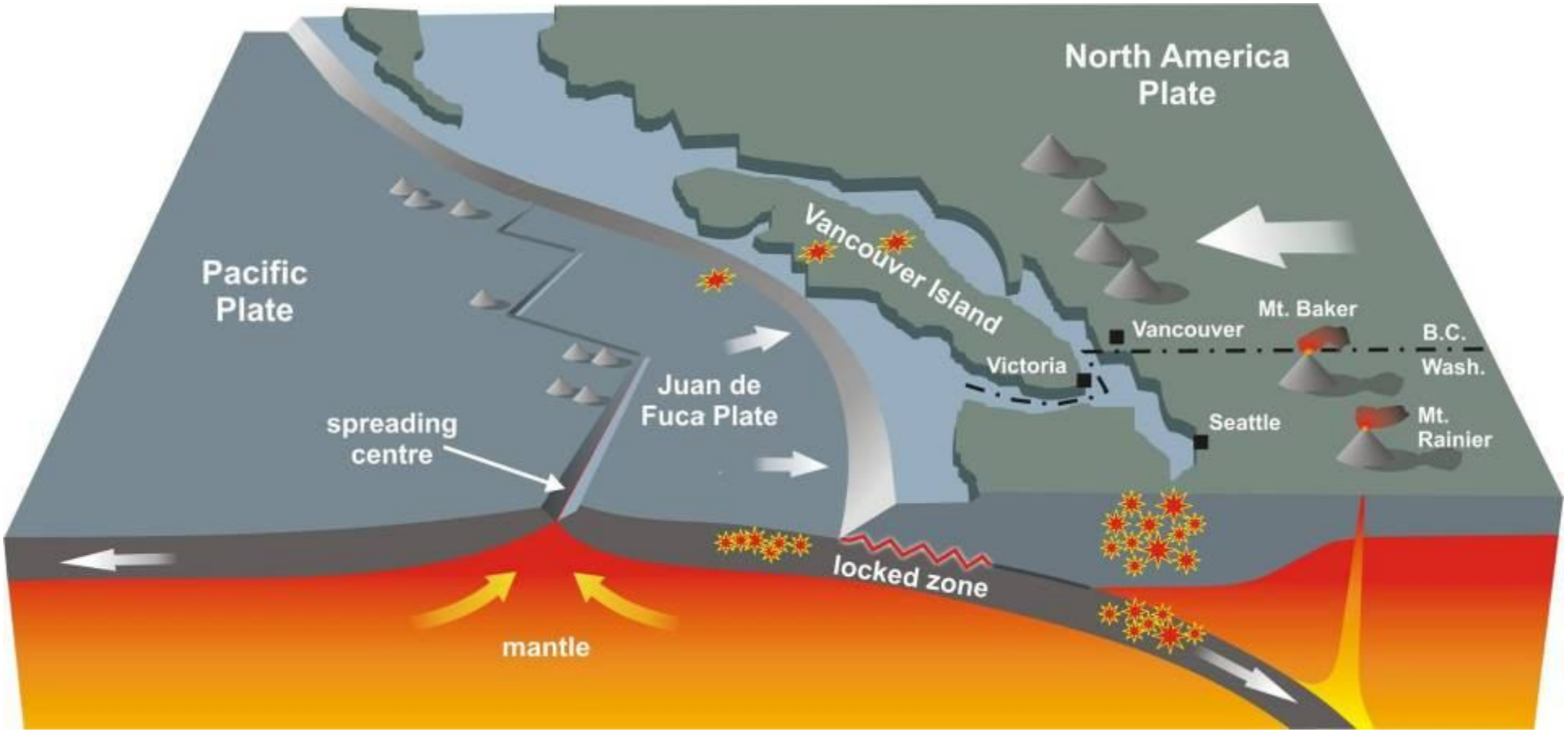



)121


R
50
48
52
46
50
44
80
78
76
74
72
70
68
66
50
48
46
44

# Earthquakes on the Cascadia Subduction Zone

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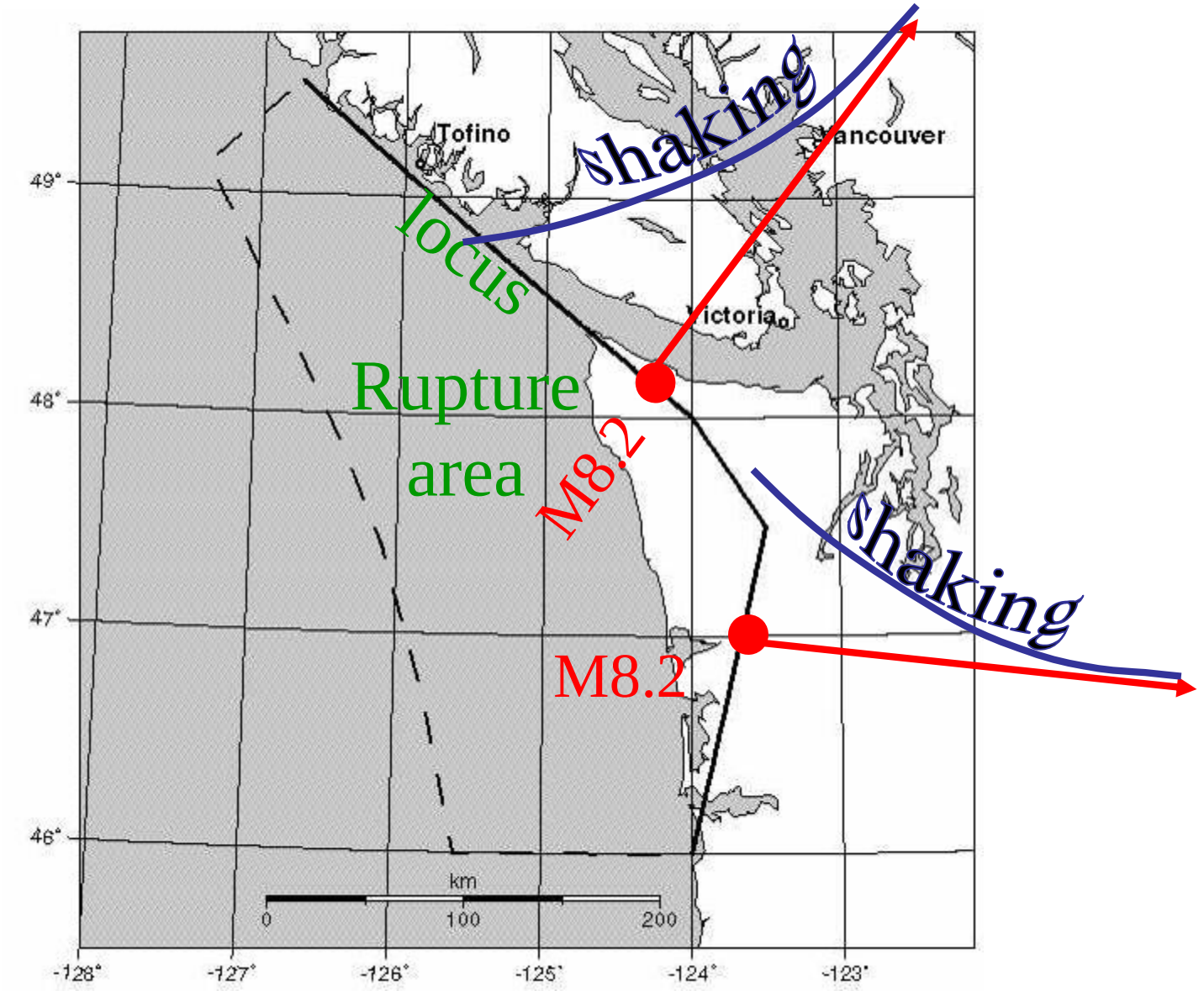
# Calculating Cascadia deterministic ground motions

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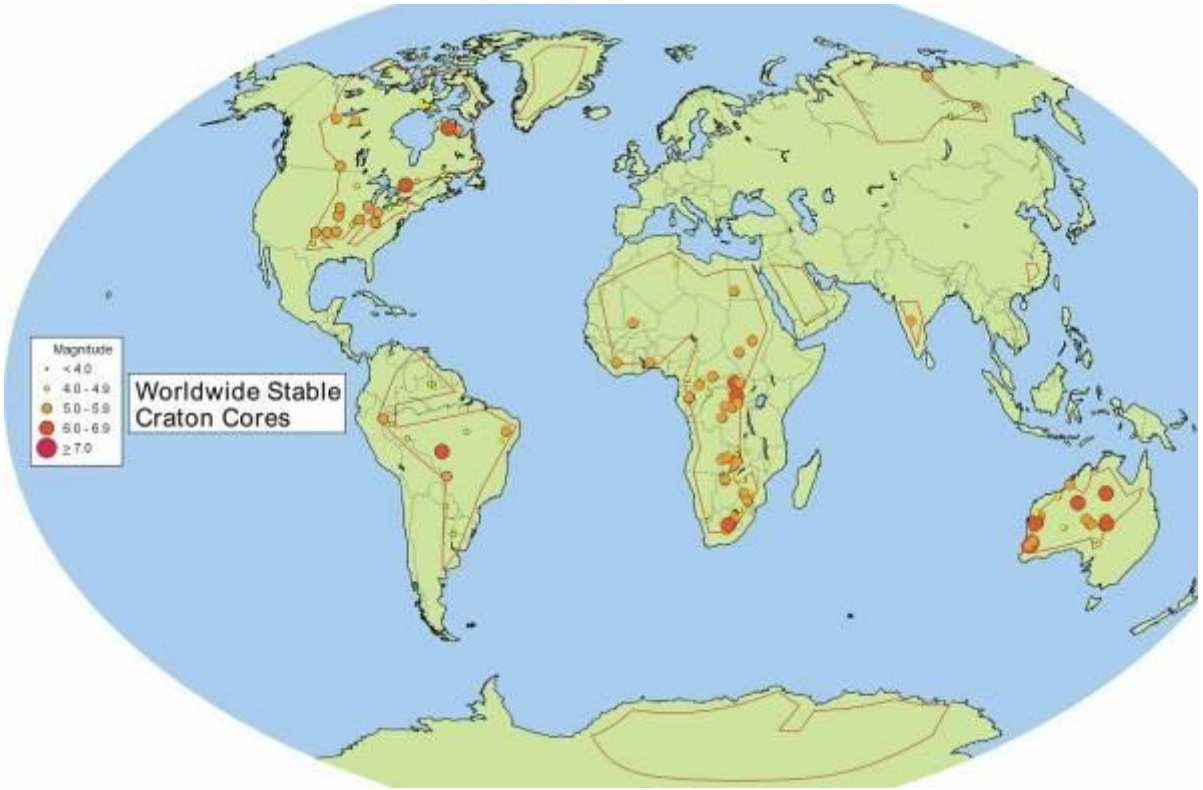
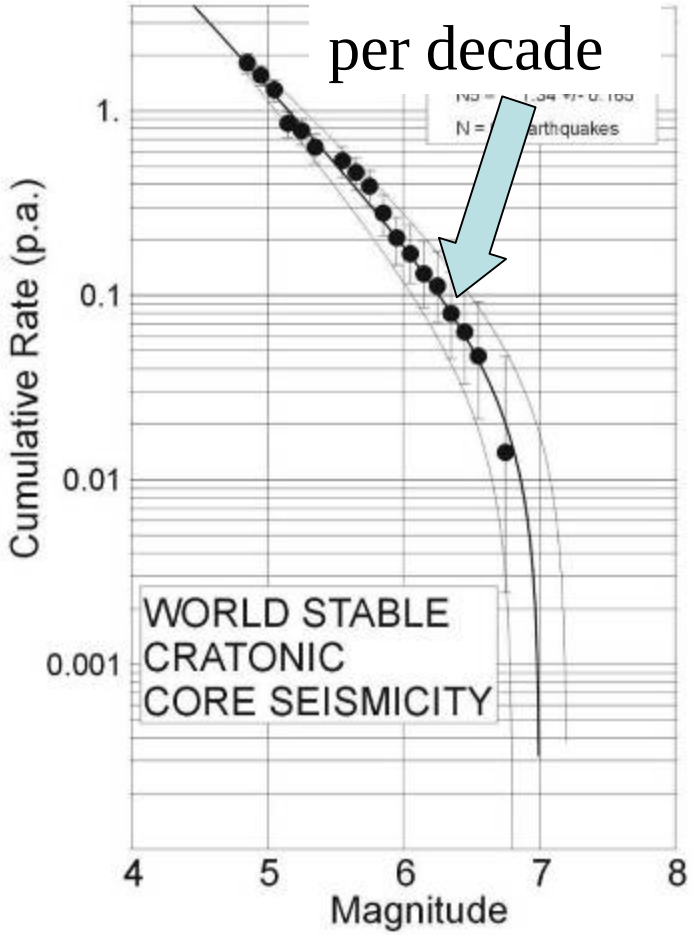
# Stable Craton - No part of the world entirely lacks (big) earthquakes




One M6.5
per decade

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# Full Robust Hazard Model

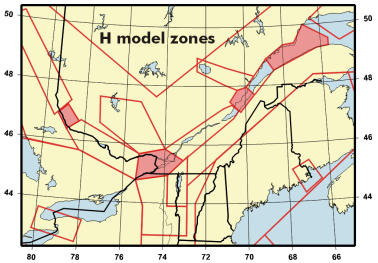
Highest value of:-

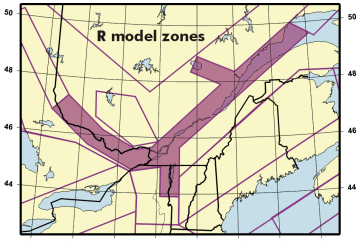
Probabilistic H model

Probabilistic R model

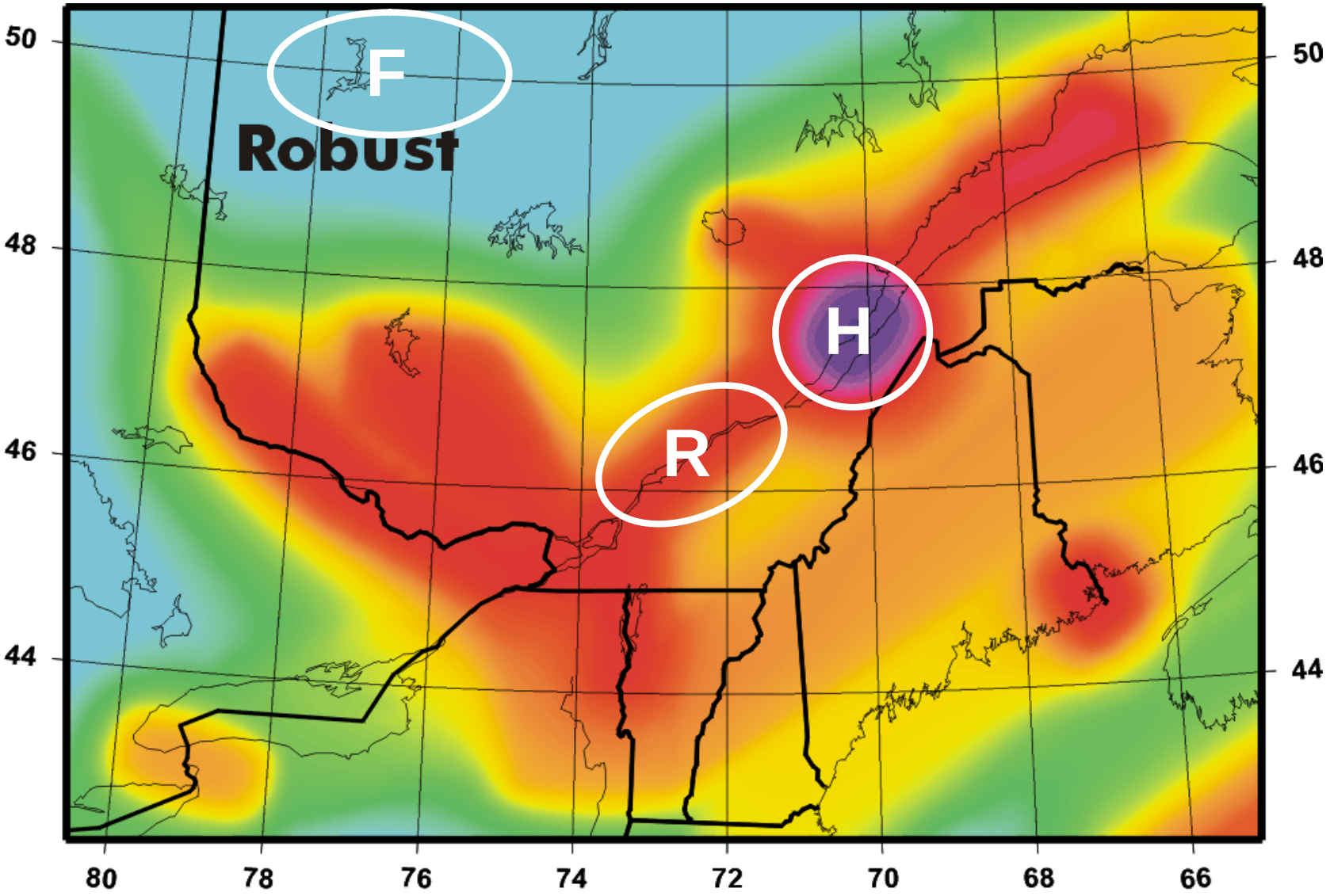
Deterministic Cascadia model

Probabilistic Stable Craton model




# Robust Hazard

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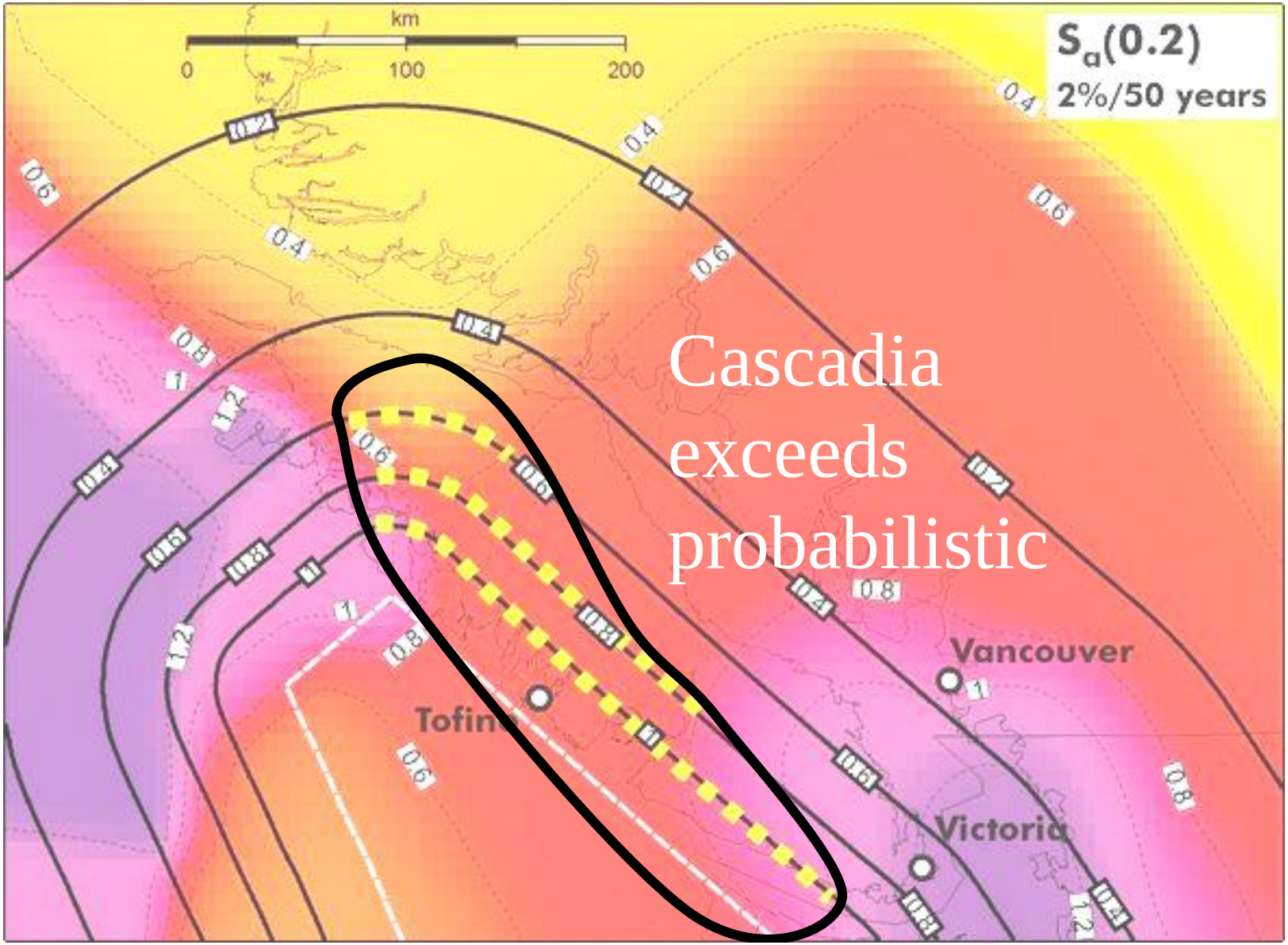
# Deterministic Cascadia plus Probabilistic hazard

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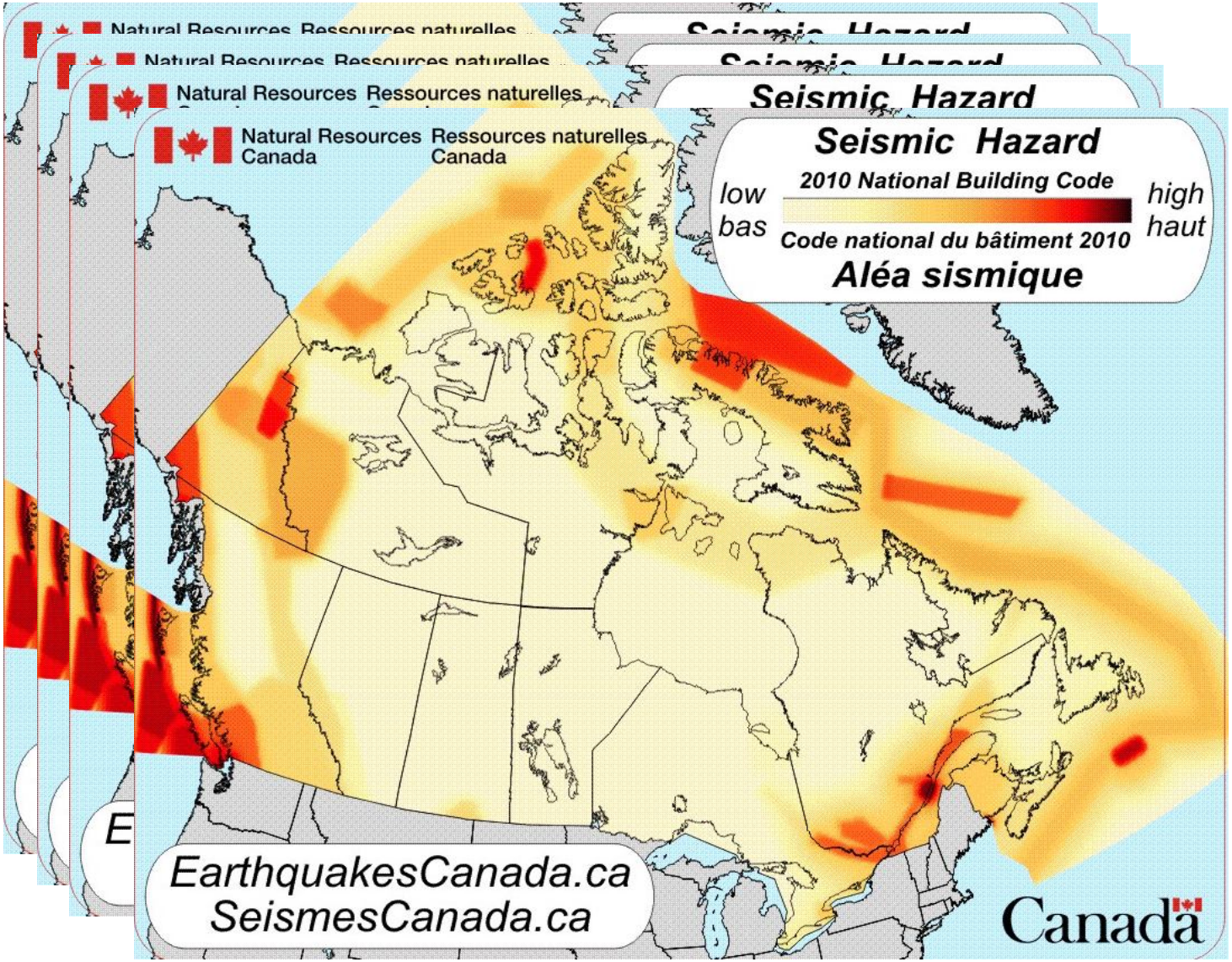
# 2010 **Probabilistic Spectral Acceleration at 0.0004 p.a.**




Issued as a model code Nov 2010; will be adopted in Provinces and Territories in 2011-2012

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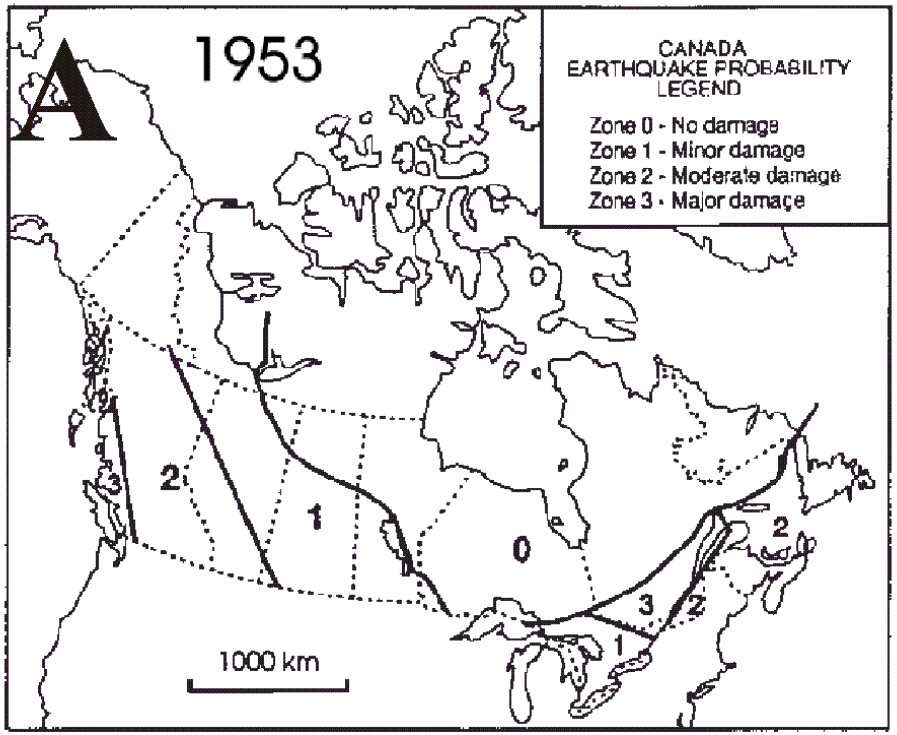
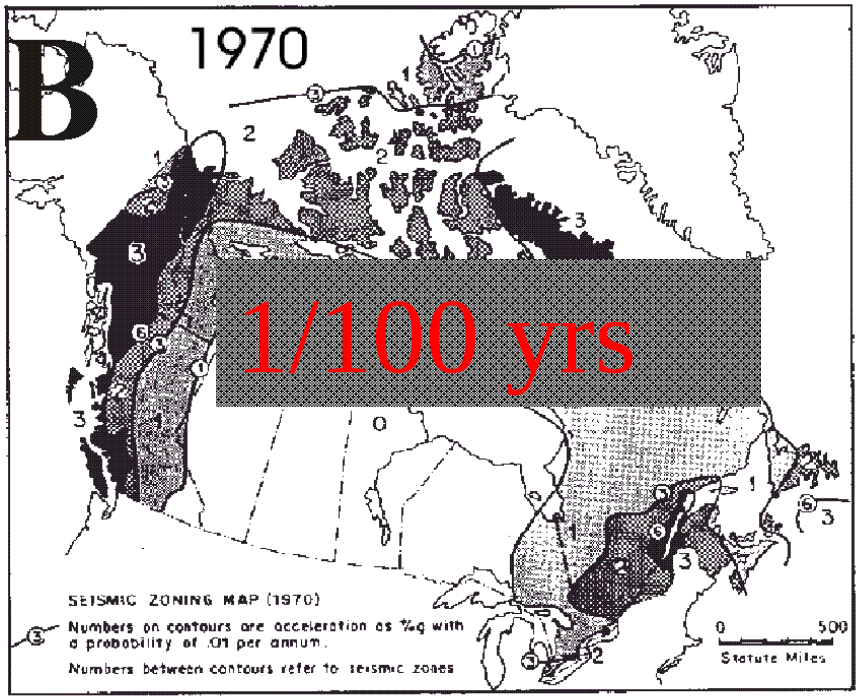
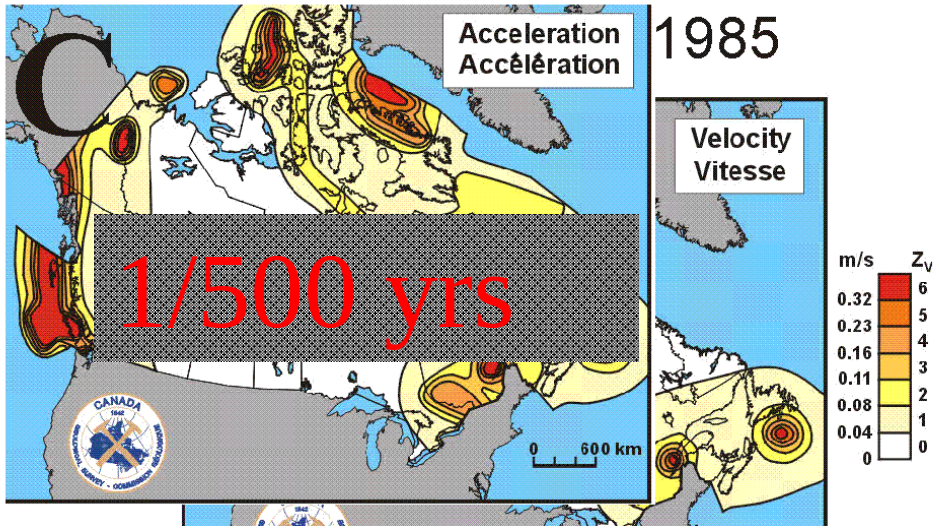
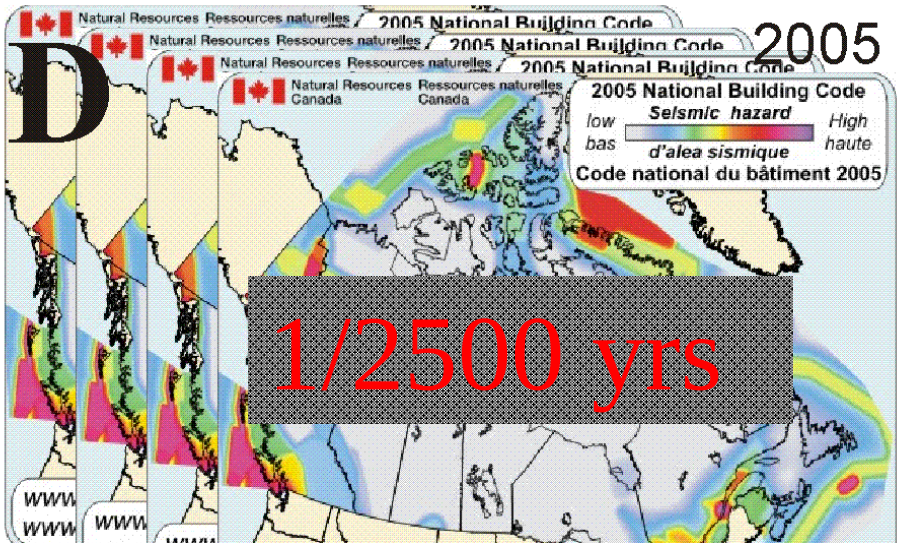

A
1953
CANADA
EARTHQUAKE PROBABILITY
LEGEND
Zone 0 - No damage
Zone 1 - Minor damage
Zone 2 - Moderate damage
Zone 3 - Major damage
1000 km


B
1970
1/100 yrs
SEISMIC ZONING MAP (1970)
Numbers on contours are acceleration as %g with a probability of .01 per annum.
Numbers between contours refer to seismic zones
0 500
Statute Miles

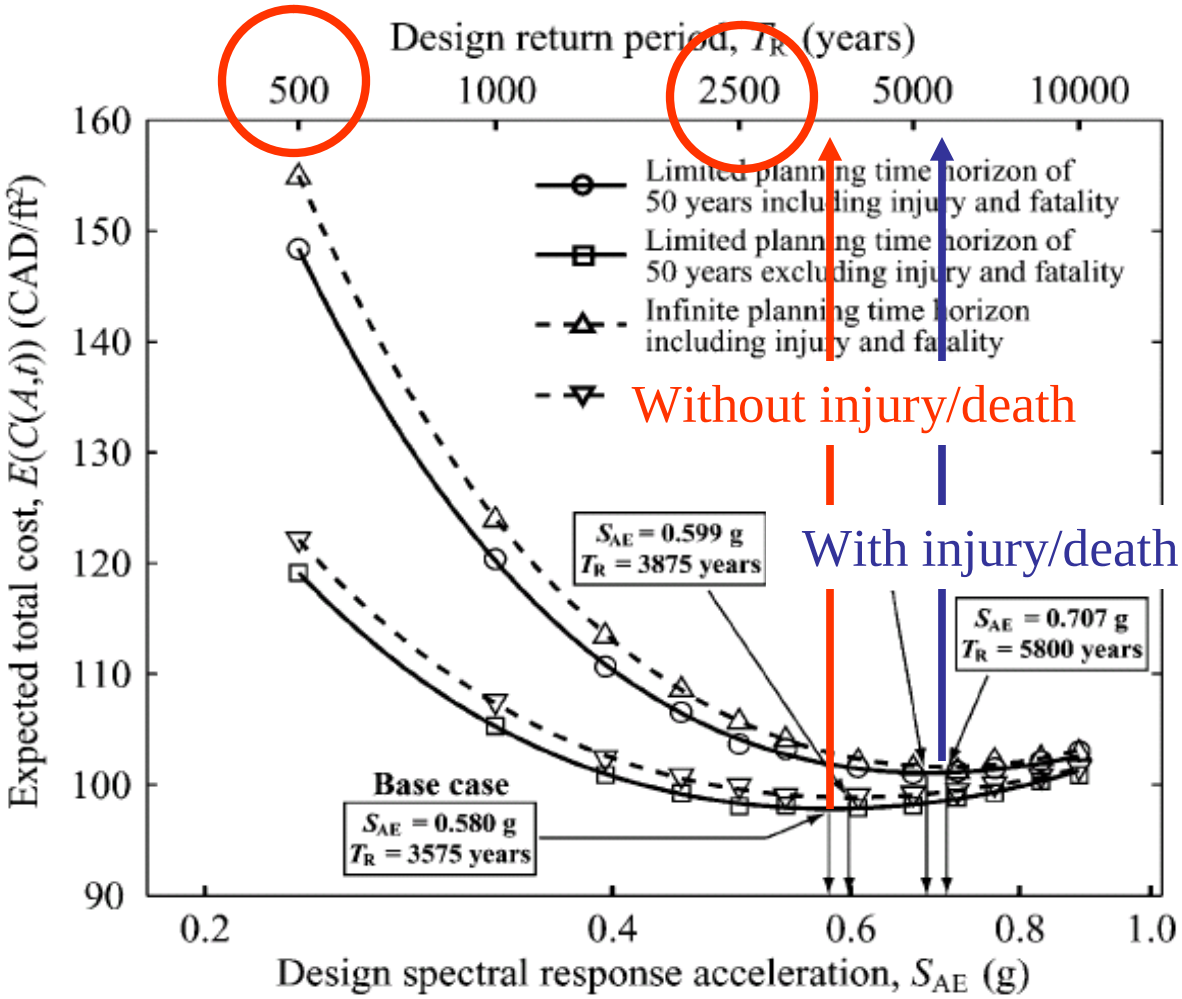

C
Acceleration
Accélération
1985
1/500 yrs
Velocity
Vitesse
m/s
Zv
0.32 6
0.23 5
0.16 4
0.11 3
0.08 2
0.04 1
0 0
0 600 km


D
2005
Natural Resources Canada
Ressources naturelles Canada
2005 National Building Code
Seismic hazard
low
bas
High
haute
d'alea sismique
Code national du bâtiment 2005
1/2500 yrs

# 0.01 → 0.002 → 0.0004 p.a. - where will it end?

Expected total cost for different seismic design loads with the infinite planning time horizon and limited planning time horizon of 50 years.

**9-storey steel structure in Vancouver**




Goda & Hong Structural Safety 28 (2006) 247–260, Optimal seismic design for limited planning time horizon with detailed seismic hazard information

# Getting the codes used

As the probability levels have dropped (better understanding that we need to design against rare earthquake shaking) the ground motions have increased, but improved engineering has mitigated cost increases

Marginal cost of earthquake-resistant design in a high-rise building is about 2-4% of the project cost – perhaps less

- The better design buys us higher confidence that the building will not collapse (should a large earthquake occur)

It also (probably) gives us

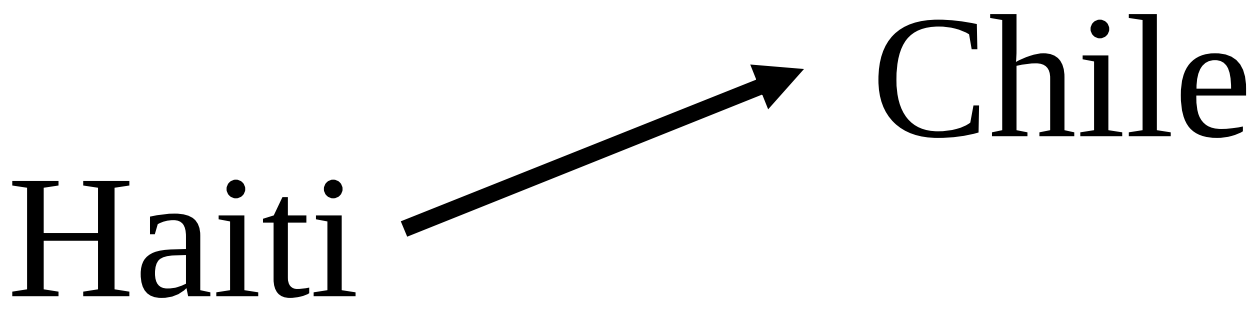
- Less damage from minor earthquakes
- Faster re-occupancy (less business interruption)
- Resistance to explosions (Oklahoma City bombing)

In an efficient insurance market, the present value of the ongoing premium reduction should balance the initial cost of exceeding the code design

# Risk Mitigation Through Building Codes

National building codes are the most cost-effective way of reducing future losses, but we need

- Good codes – community consensus on acceptable cost/risk balance
- Followed properly – design engineer
- Using quality materials – suppliers
- Implemented during construction – site engineer
- Inspected as being constructed – municipal regulations
- Wanted by the community – general public



**Increases in code requirements may be resisted!**

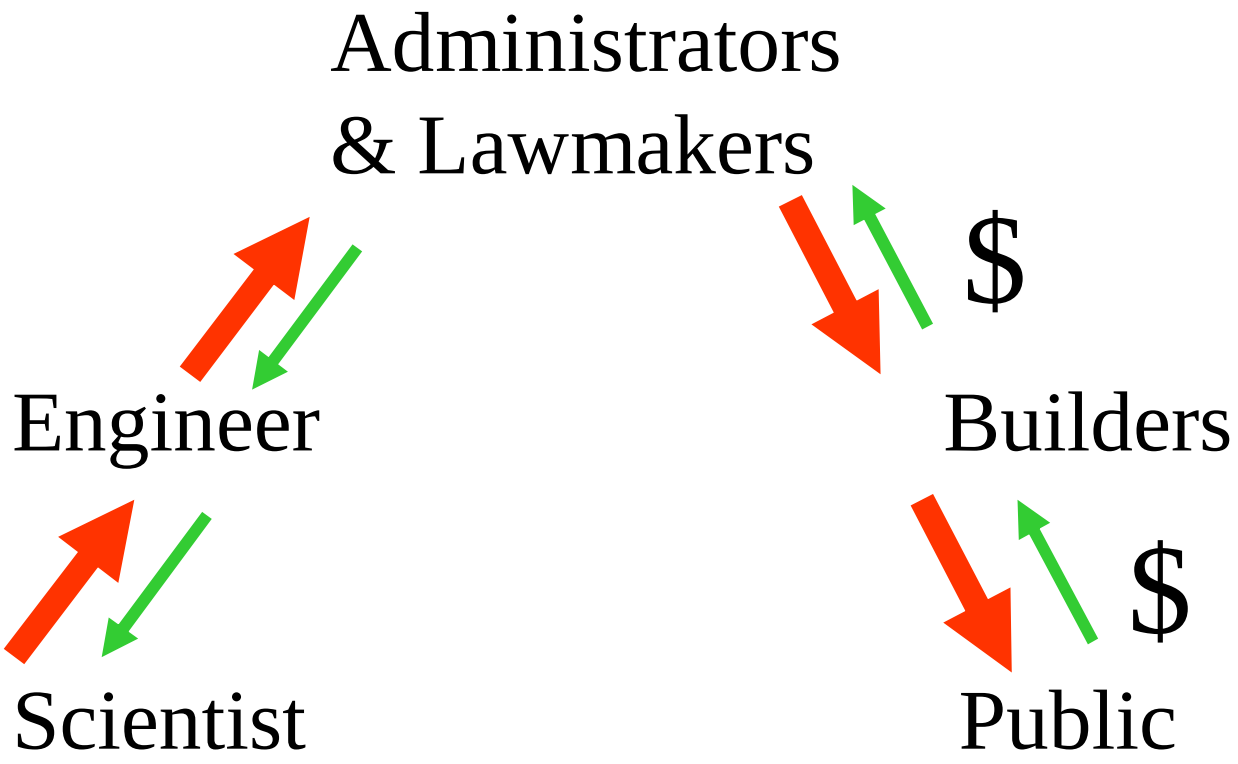
they increase today's costs with no immediate return, but

may be required to attain life-safety

or

may be justified on economic grounds (present cost versus future loss)

To achieve the best end result, a "decision snake" is necessary:

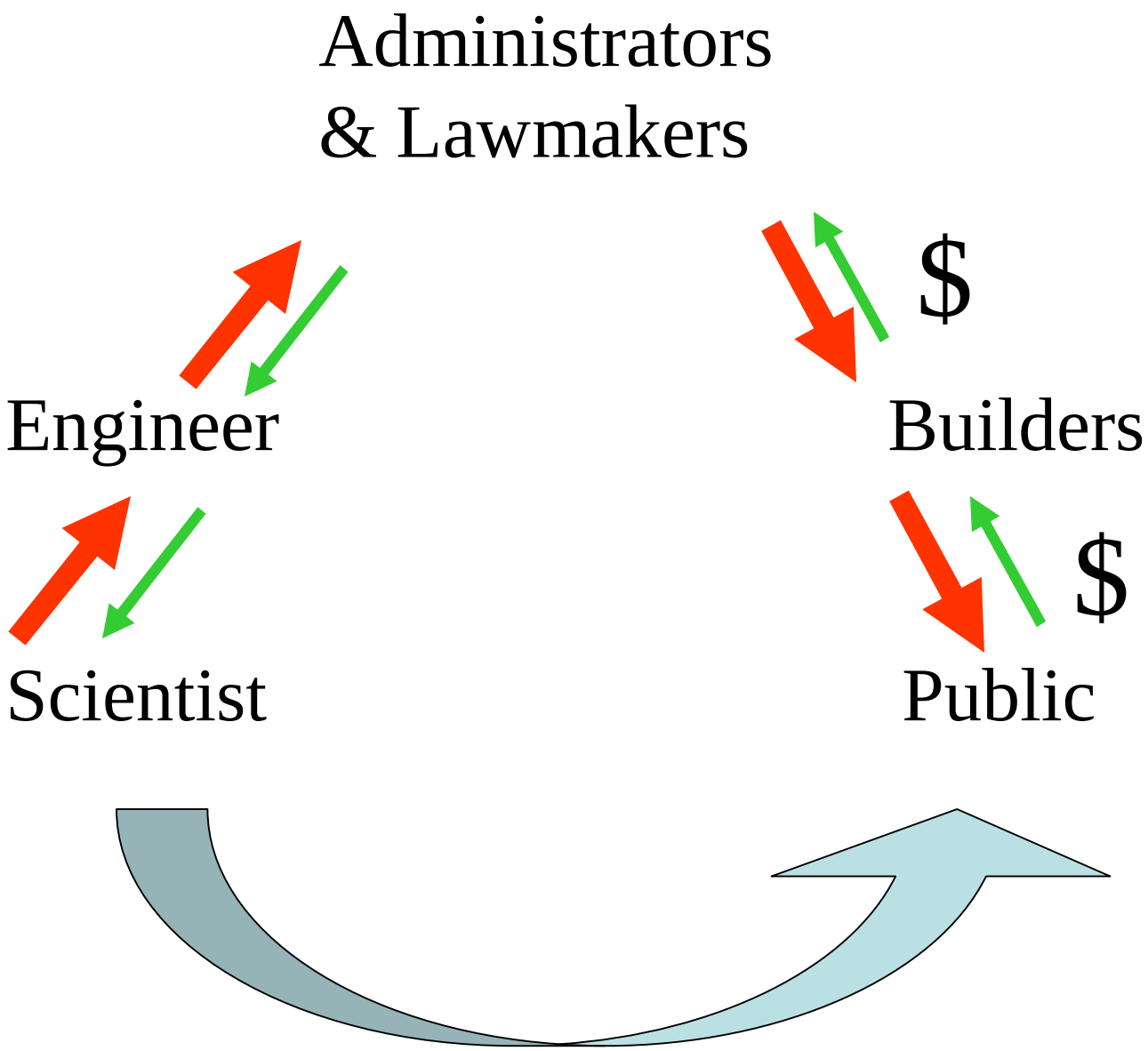


Top-down doesn’t always work (e.g. country Xxx)

Canadians are best able to participate in the decision snake when they understand the risks.

Therefore the scientist needs to communicate earthquake hazard to the general public so that there is a good appreciation that the short-term costs will ultimately save lives, save money and increase human happiness.

The insurance industry could help by increasing public awareness, and pricing products to reward earthquake-resistant buildings

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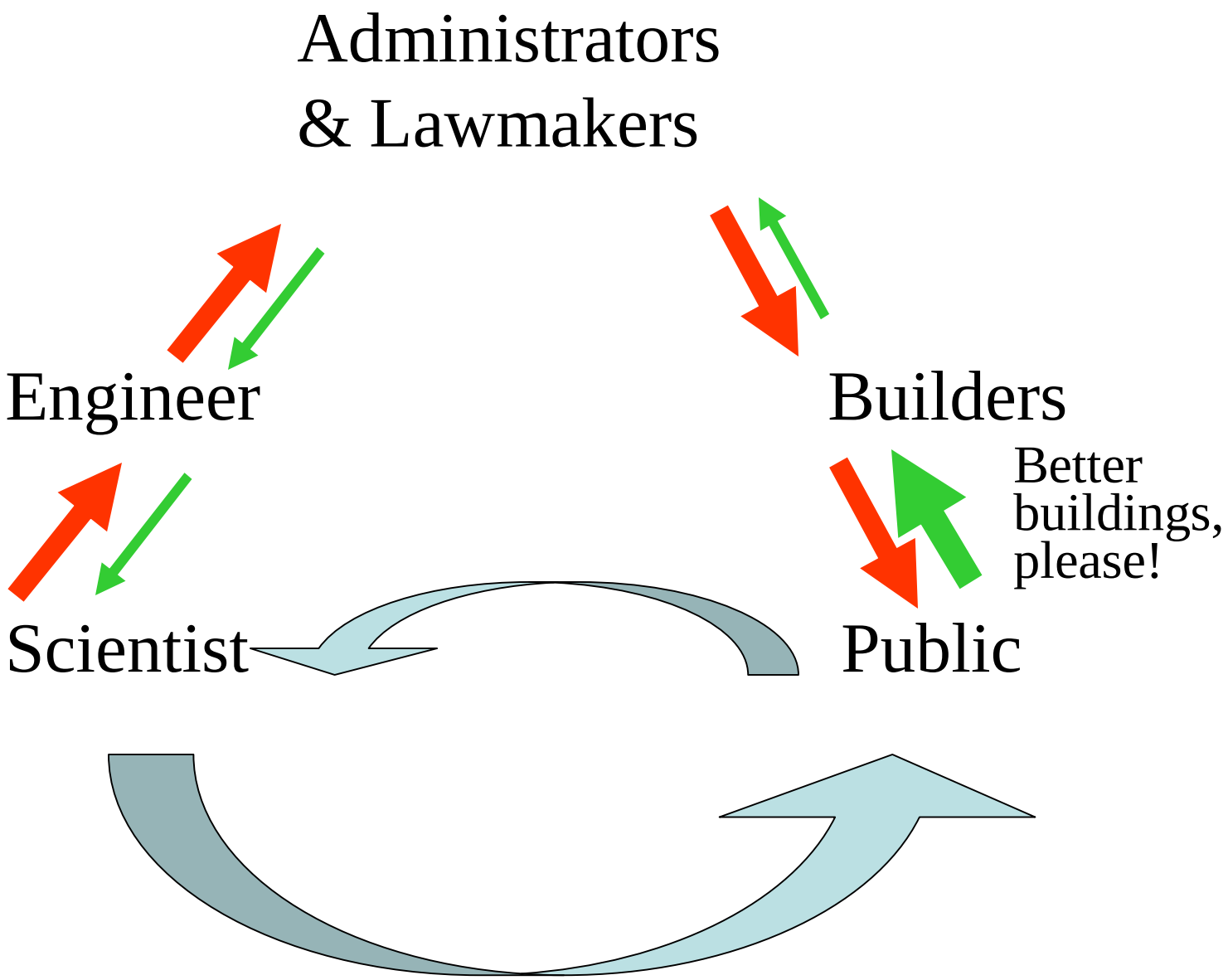
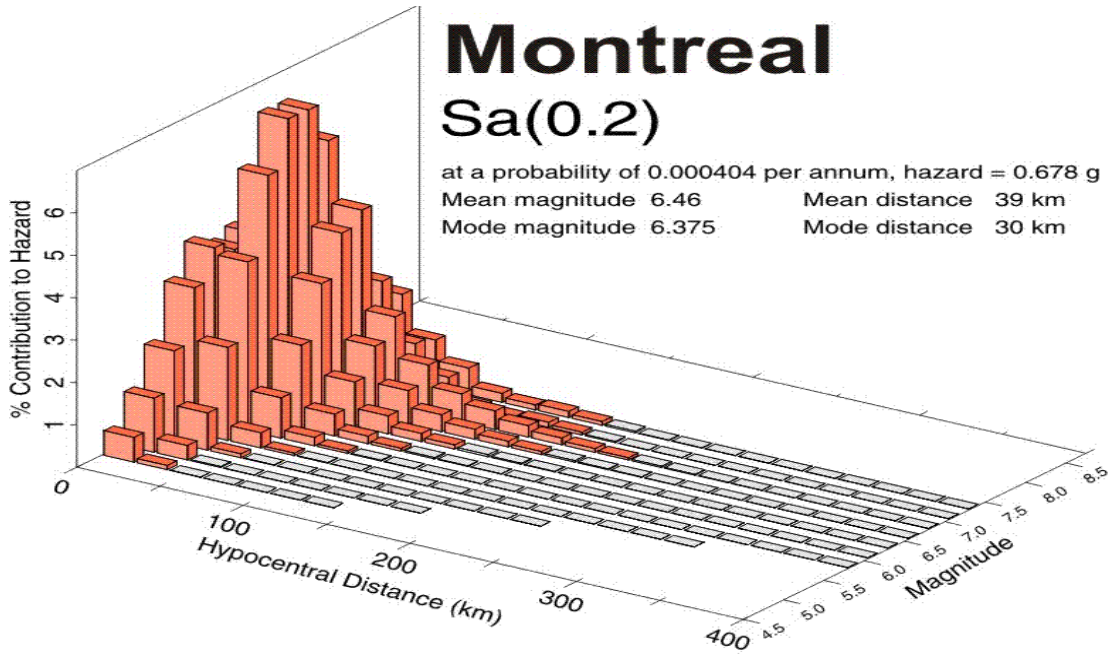

Administrators
& Lawmakers
Engineer
Builders
Better
buildings,
please!
Scientist
Public

# Building codes alone are not enough

# Risk Mitigation of "Small" Earthquakes Through Building Codes

Deaggregations of seismic hazard → scenario earthquakes
catastrophic losses → large-magnitude earthquakes (M ~6½ and larger)




But smaller "Newcastle-sized" earthquakes (M ~5) are
- more common
- similar to events represented in the historical catalog
- more relevant to the current population

# RISK MITIGATION OF "SMALL" EARTHQUAKES THROUGH BUILDING CODES

The "small" earthquakes taken to be M << 6. These usually

- do not necessarily cause collapse in many buildings
- radiate lots of short-period energy, which makes them very damaging to short, rigid structures (like brick houses);
- therefore threaten the majority of built infrastructure in suburbs and small towns.
- do not threaten long-period "important" engineered buildings common in cities

Damage may be of low intensity and localized, but can accumulate to large losses if the "small" earthquake is under a suburban/urban area. "Small" in this context might include magnitude 4.5 or even 4.0

Examples include

| | | |
|---|---|---|
| 1989 Newcastle, Australia | M5.6 | $2000M |
| 1944 Cornwall, Canada | M5.8 | $20+M |
| 2003 Ste Agathe de Fossili, Italy | M4.9 | ?? |
| 2007 Folkestone, U.K. | M4.3 | ?? |
| 1994 Cacoosing Valley, Pennsylvania | M4.2 | $2M |

# Newcastle Australia Earthquake Magnitude 5.6

**~ 40,000** homes damaged

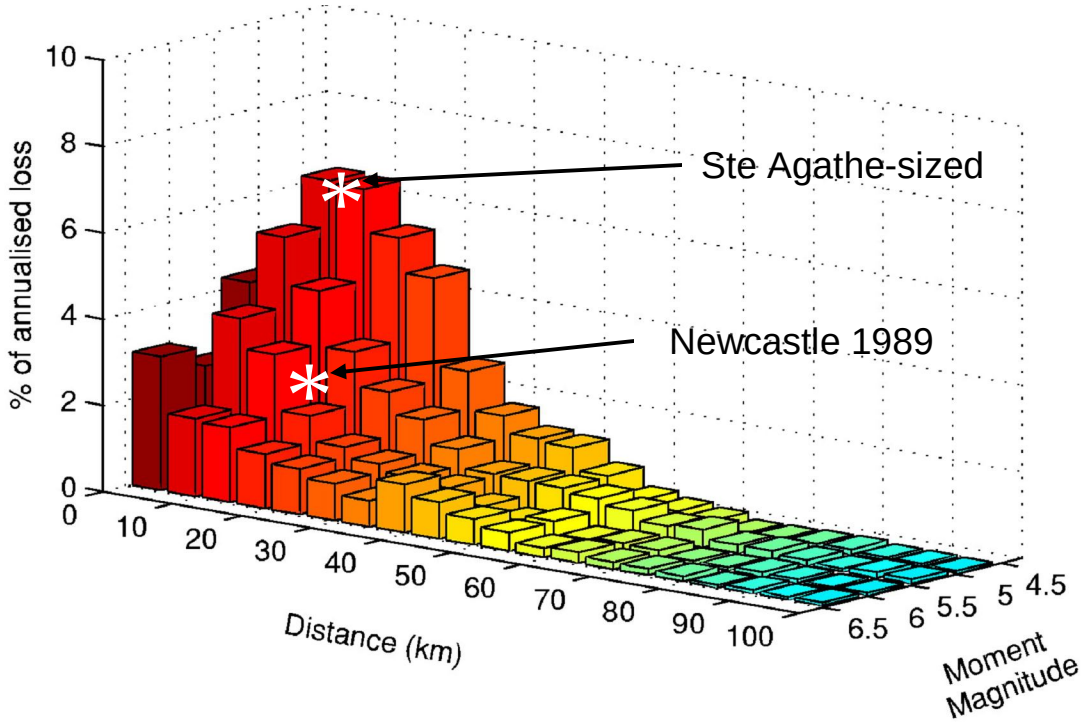
- **300** buildings were demolished
- **1,000** were made homeless
- **300,000** people were affected
- damage ~ **A$2-4 billion**

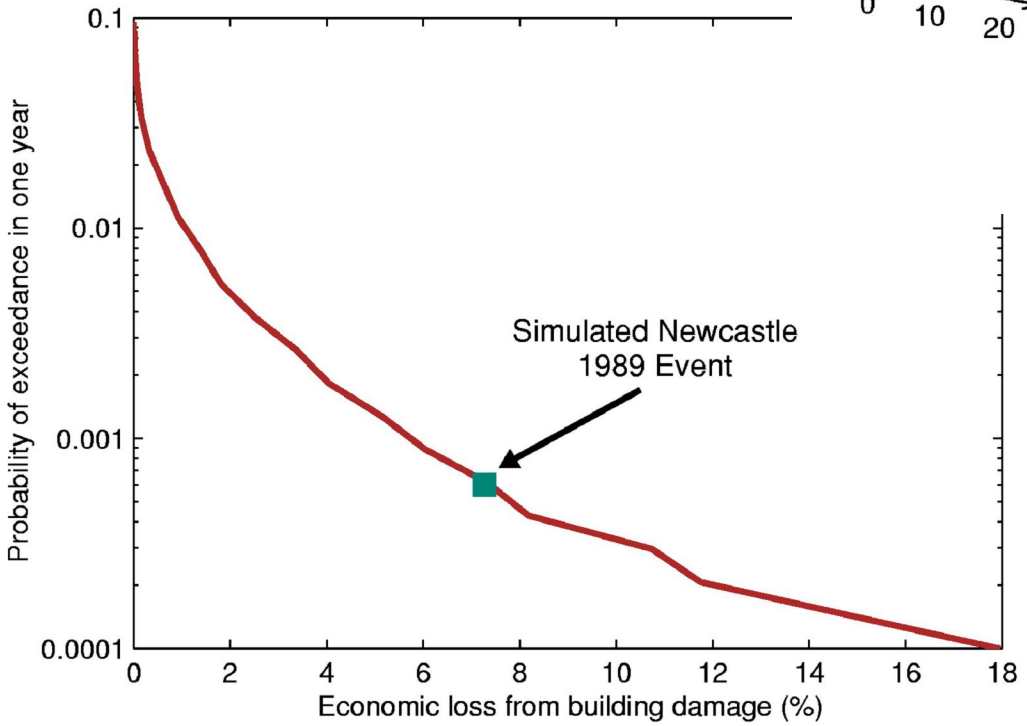
# Cornwall, 1944
# Magnitude 5.8

damage ~ **$15 million**

Ste Agathe de Fossili,
Italy 2003
Magnitude 4.9

Earthquakes smaller than 1989 contribute significant loss for Newcastle-type events




**We need to think in terms of the portfolio of a nation's suburbs**

**Source: Geoscience Australia Record 2002/15**

***Edited by Trevor Dhu and Trevor Jones***

J Adams 20110121

# Risk mitigation of "Small" earthquakes can't be done entirely through Building Codes

What is the correct mitigation strategy?
Building codes best in preventing collapse in "large" buildings shaken to the design event

New houses could be made much more earthquake-resistant during construction

but likely only as part of a complete disaster mitigation strategy including enhanced resistance to other natural disasters, especially meteorological ones.

But even a small incremental cost is considered a significant barrier to home ownership.

Retrofit existing houses?

common strong shaking in California makes improved anchoring of house to the foundation cost-effective (i.e. a few thousand dollars can offset a few hundred thousand dollars in loss)

Such mitigation is probably not cost-effective in most parts of eastern Canada
probability of strong shaking is too low

So perhaps no single engineering answer?

Slowly-improved materials standards (masonry ties)
better planning for the post-disaster recovery phase?
rapid economic follow-through (including insurance pay-outs)?

are the most effective overall mitigation strategy for suburbs in low seismicity regions.

**Notes on insurance coverage for small-earthquake / large-loss scenarios**

**These will typically be eastern Canadian earthquakes**
**Few carry household earthquake insurance**
**For those with earthquake insurance, the $ deductible is very large**

**→Much of the personal loss is not insured / not insurable in Canada**

.

## Compare New Zealand's approach

If you have fire insurance the (included )EQCover covers earthquakes to NZD100,000 for residence and 20,000 for contents

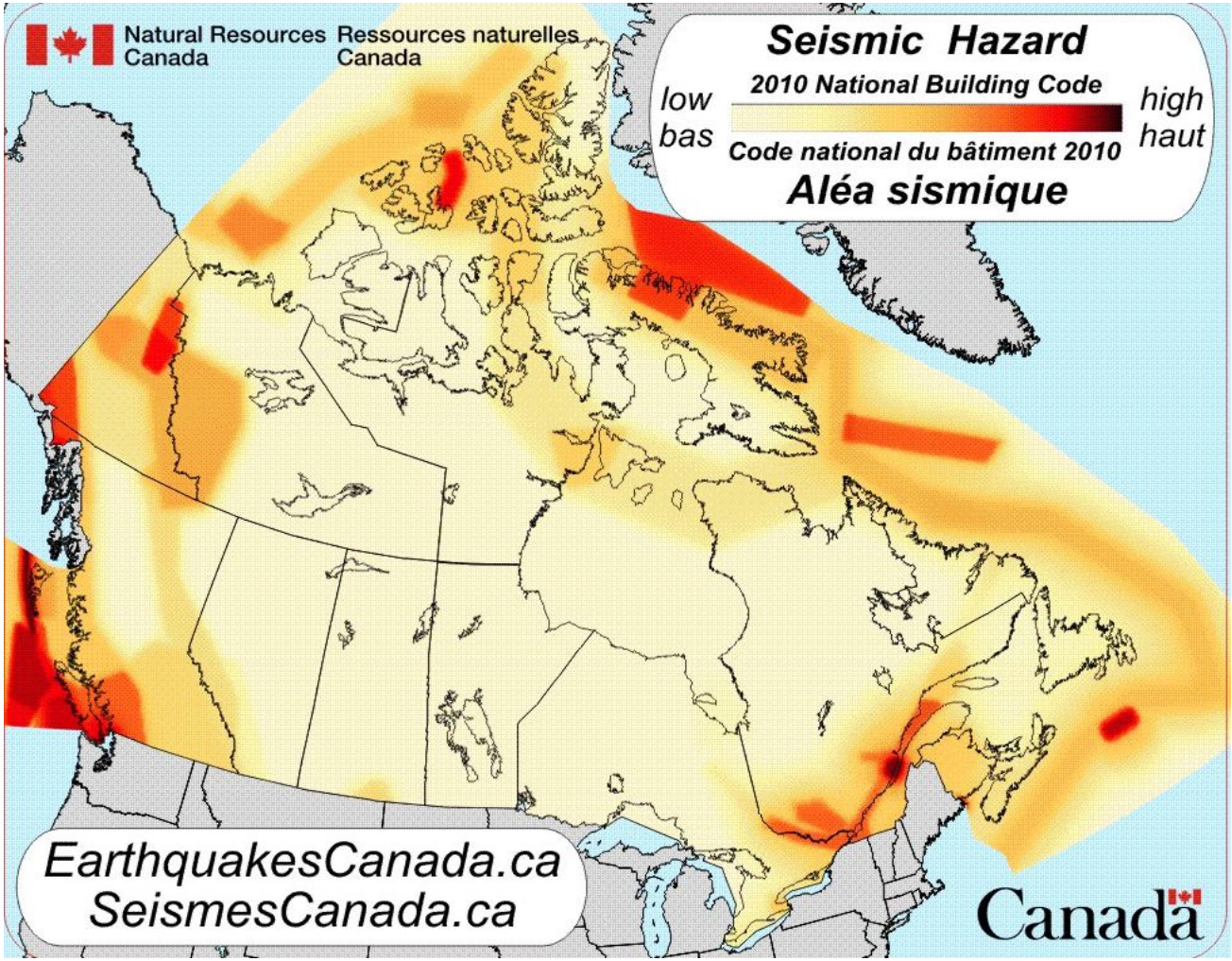
- Deductible is NZD 200
- Fee max NZD67.50/year
- Also covers specified natural disasters: landslides, volcanoes, tsunami; consequent storm or flood from these; fire-following earthquake
- subsidence (even earthquake-induced following liquefaction) may not be covered
- You can buy extra from your insurance agent to cover the remainder above 100K
- Does not cover damage to cars
- Does not cover post-event accommodation
- Aims to settle claims in one month .

# And on a personal note - what can I do?

- Be informed – understand the risks from earthquakes
- Don’t believe predictions, be wary of forecasts
- Be prepared!
  - prepare as for other emergencies - plan to have access to food, water, warmth, information
- If strong shaking occurs
  - take cover and wait for the shaking to end
  - don’t panic
  - assist your family and neighbors

Building codes will help, but must be complemented by emergency preparedness/management and post-disaster fiscal management

# www.EarthquakesCanada.ca




# Thank You

J Adams 20110121