Eastern Canadian Seismicity and current cross-border differences in assessed seismic hazard

John Adams and Stephen Halchuk,
Canadian Hazard Information Service,
Geological Survey of Canada,
Ottawa, Canada

USGS hazard workshop, Boston, 2006 05 09

Seismicity

Earthquakes M>7

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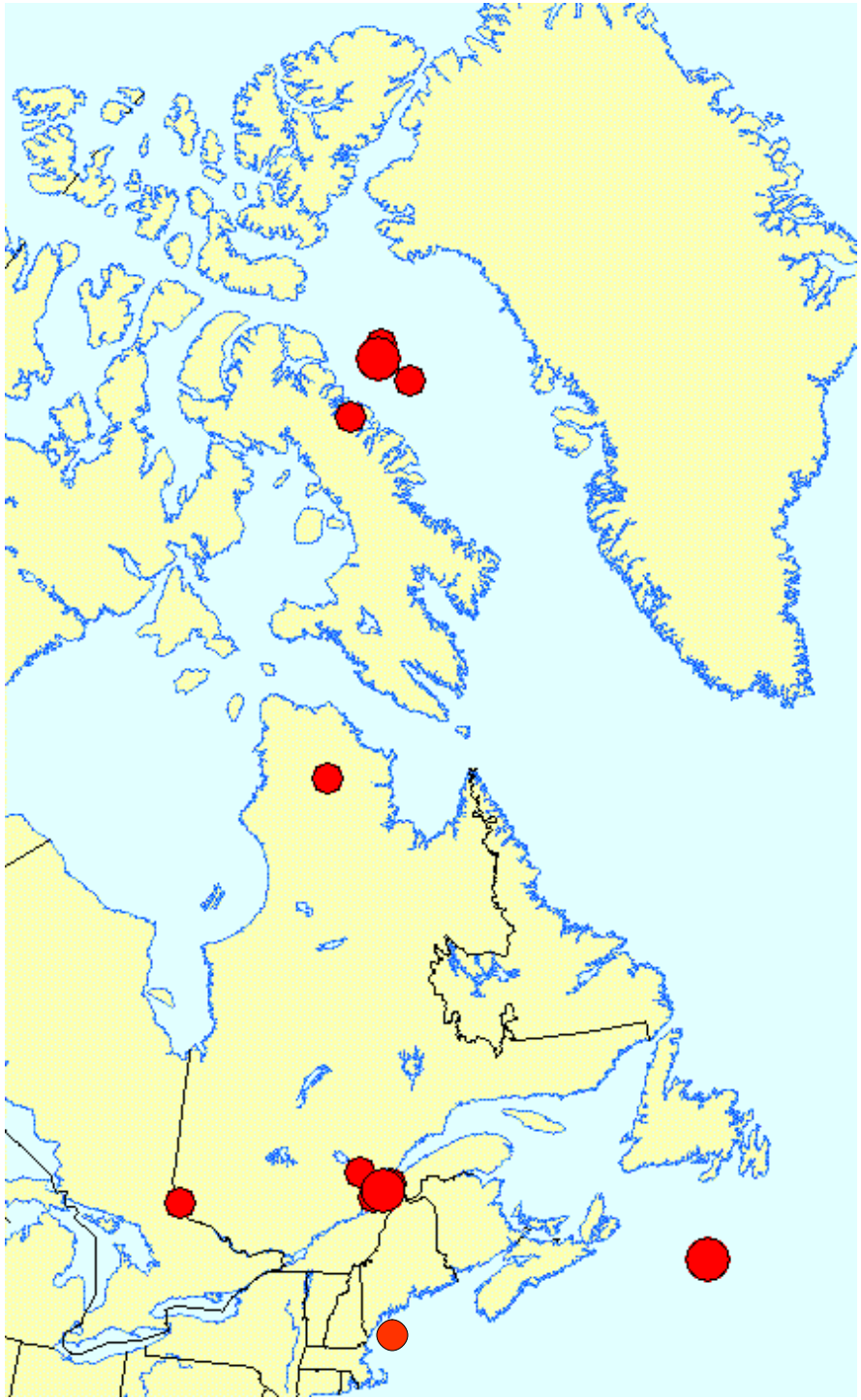
Earthquakes M>6



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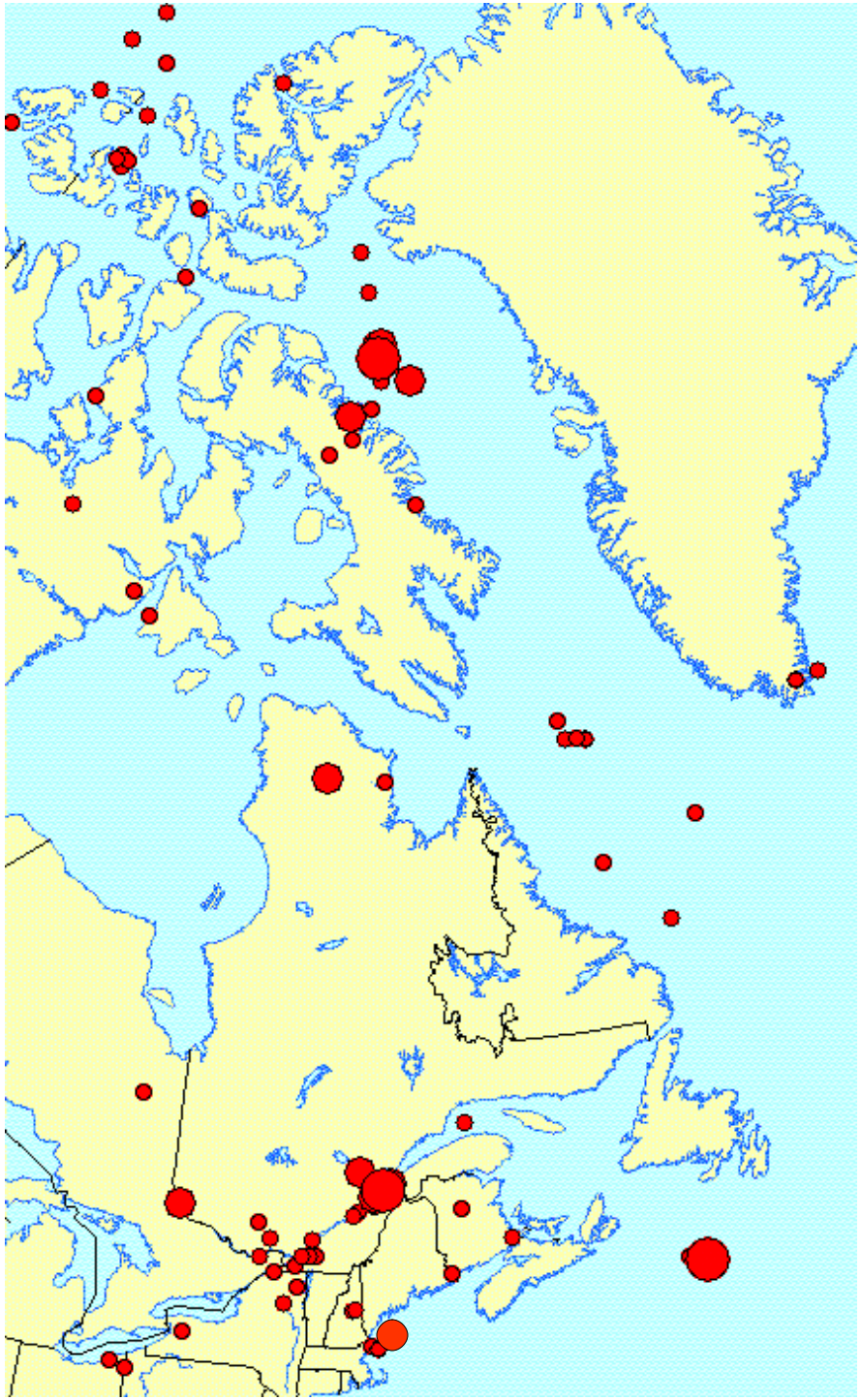
Earthquakes M>5



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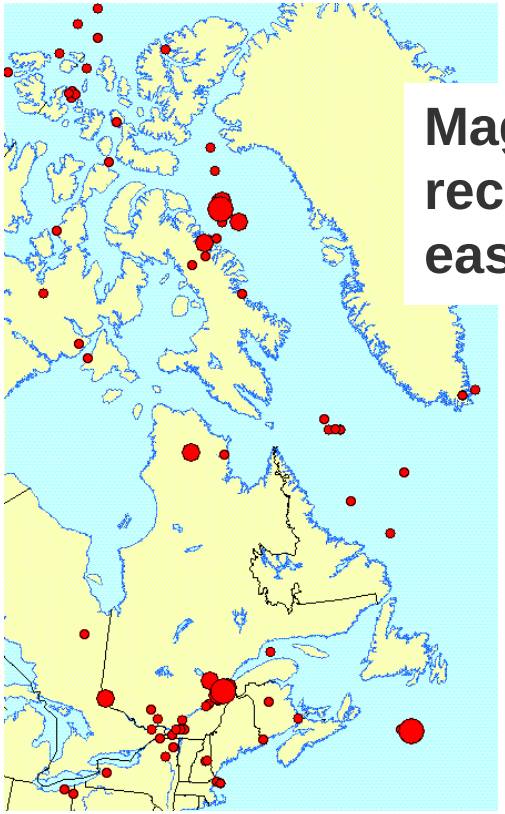
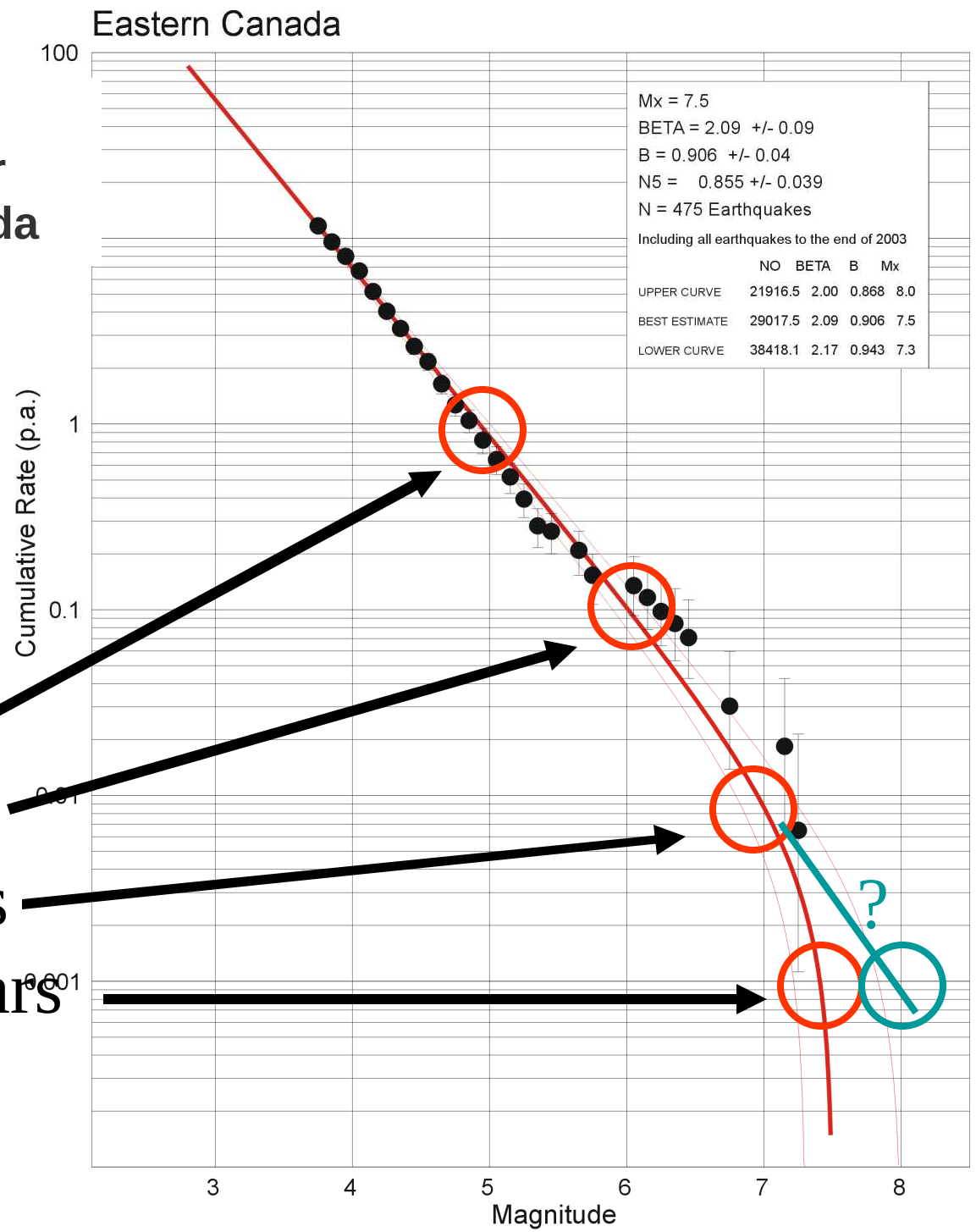


Magnitude-recurrence for eastern Canada



one M5.0 in 1 year

one M6.0 in 10 years

one M7.0 in 100 years

one ~~M7.4~~ in 1,000 years

M8 ?

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So, how to decide size & rates of largest earthquakes?

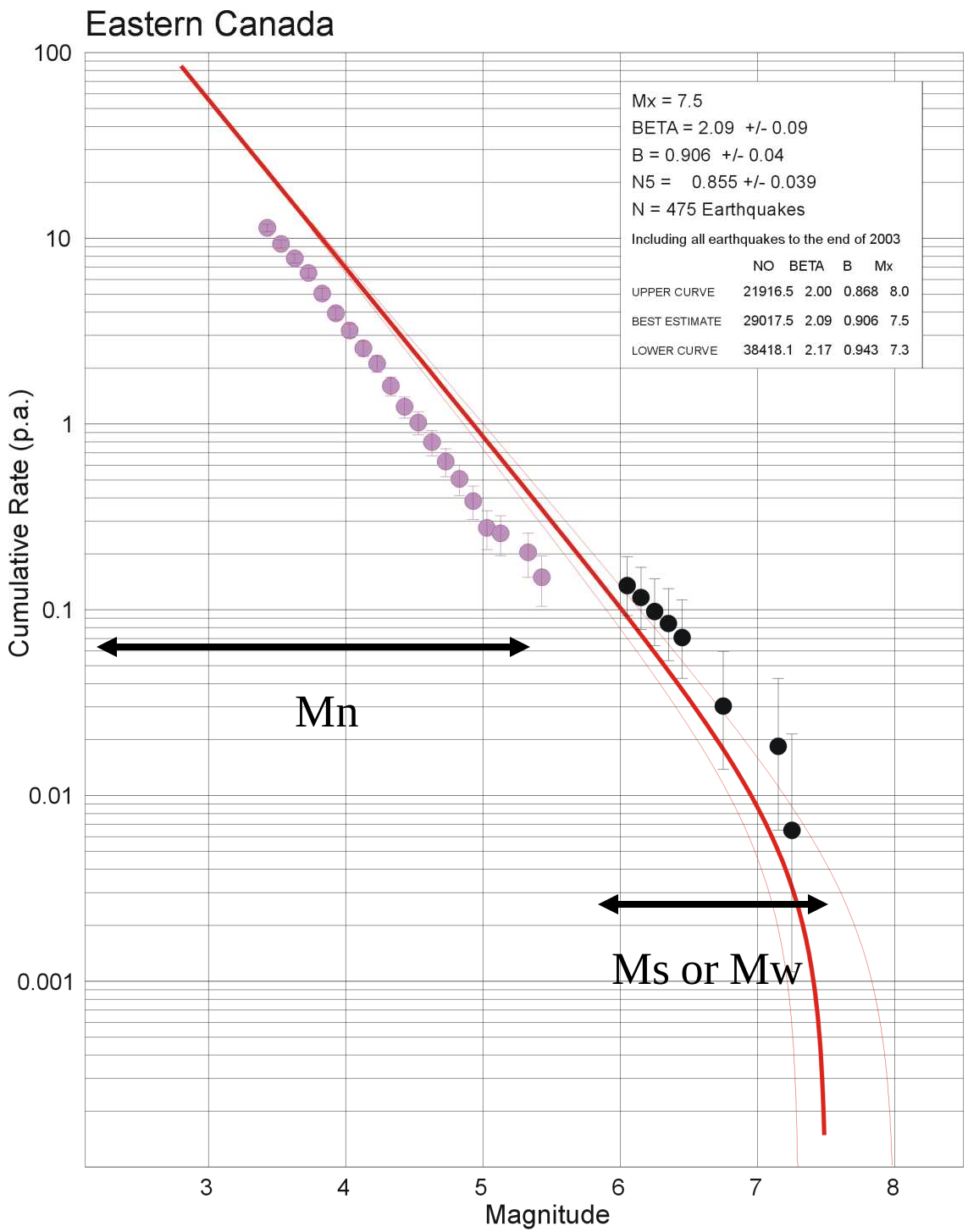
- Seismicity
- Paleoseismology
- Contemporary deformation rates

Seismicity

Improve extrapolation - try to correct inconsistency in magnitude scales

Mw = Ms

Mw = Mn – 0.4



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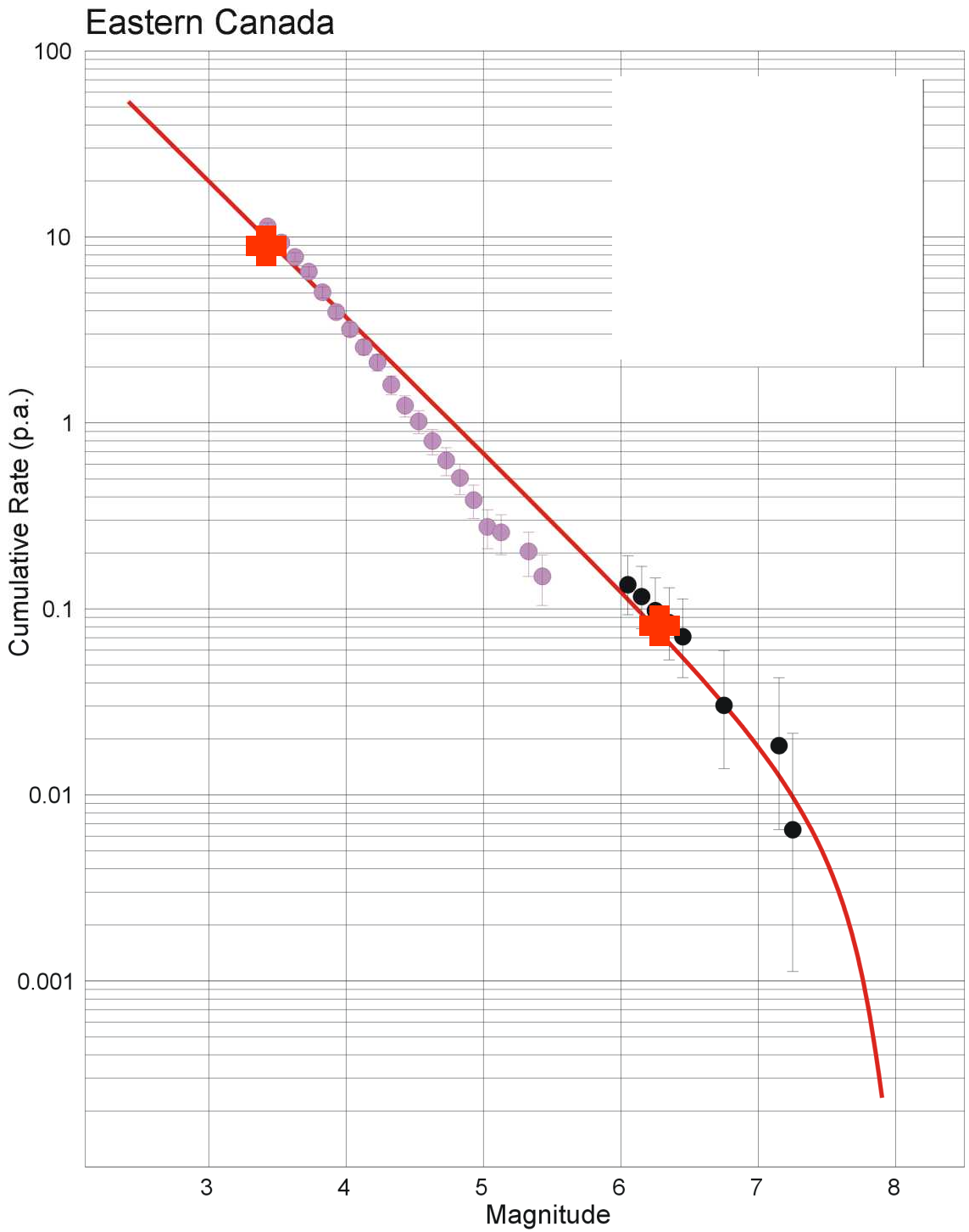
Possible revised fit through M3, M6



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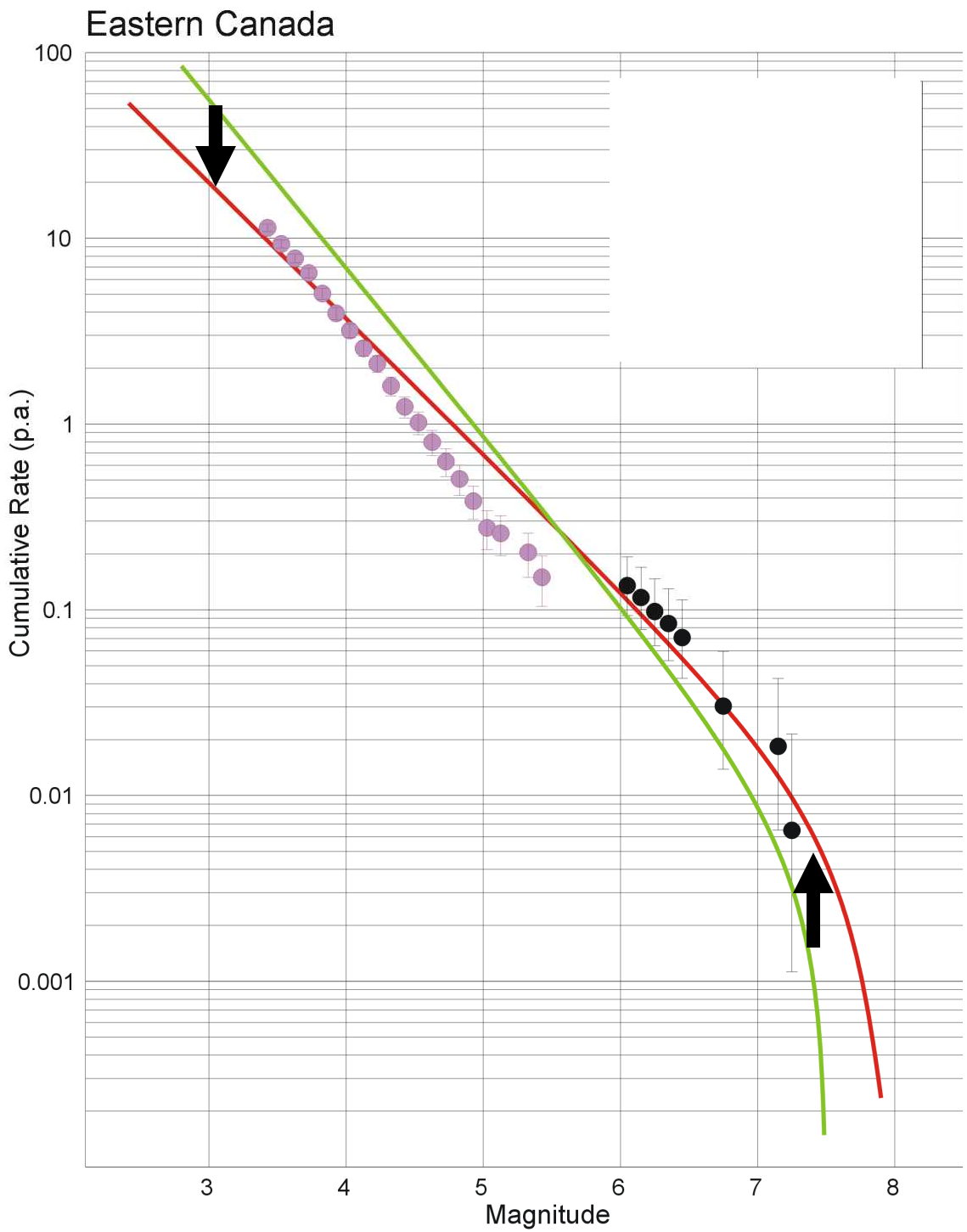
Rate of largest earthquakes increases by factor >2

Larger Mx?



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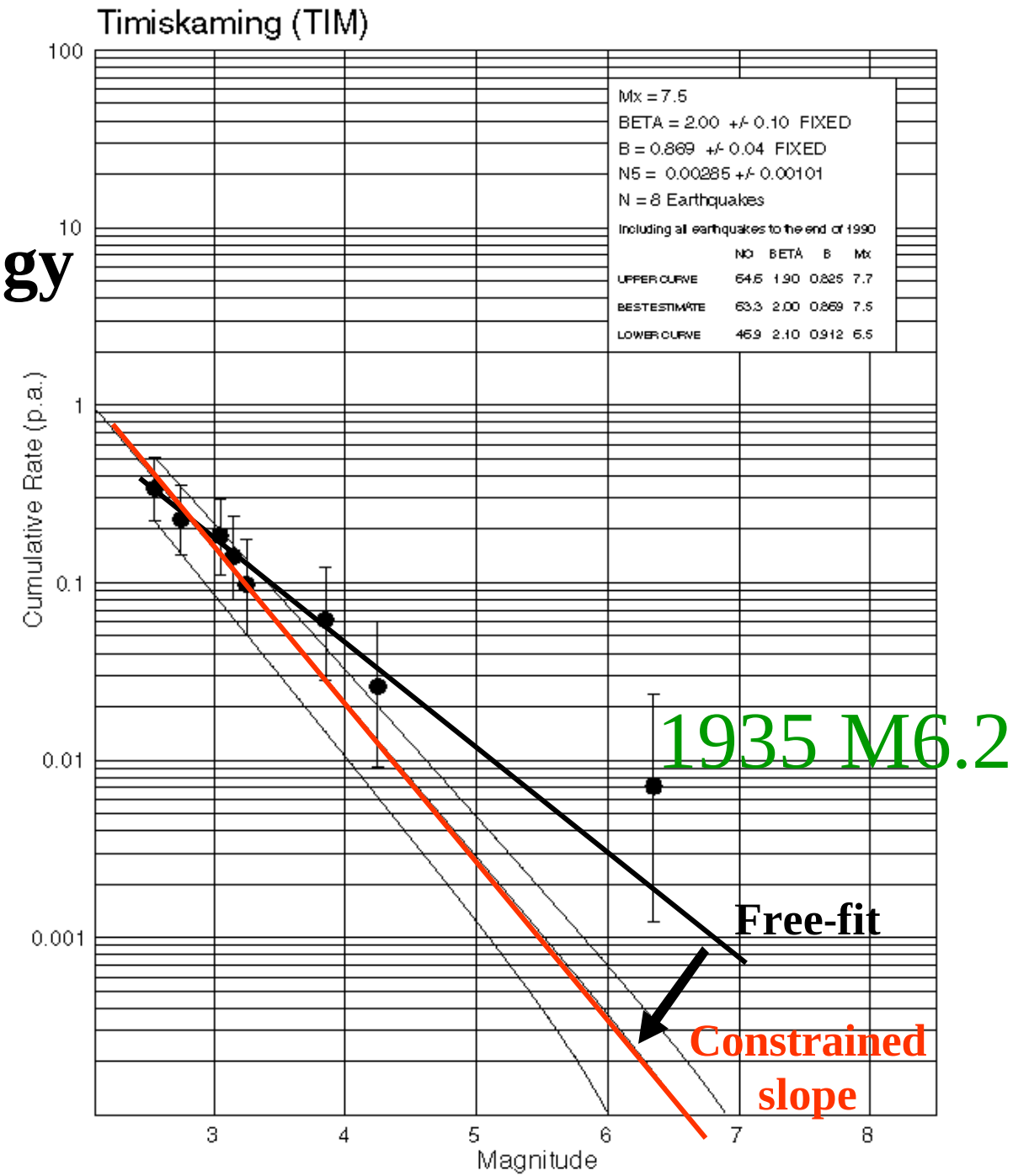
Paleoseismology

Earthquakes near 1935 Timiskaming earthquake



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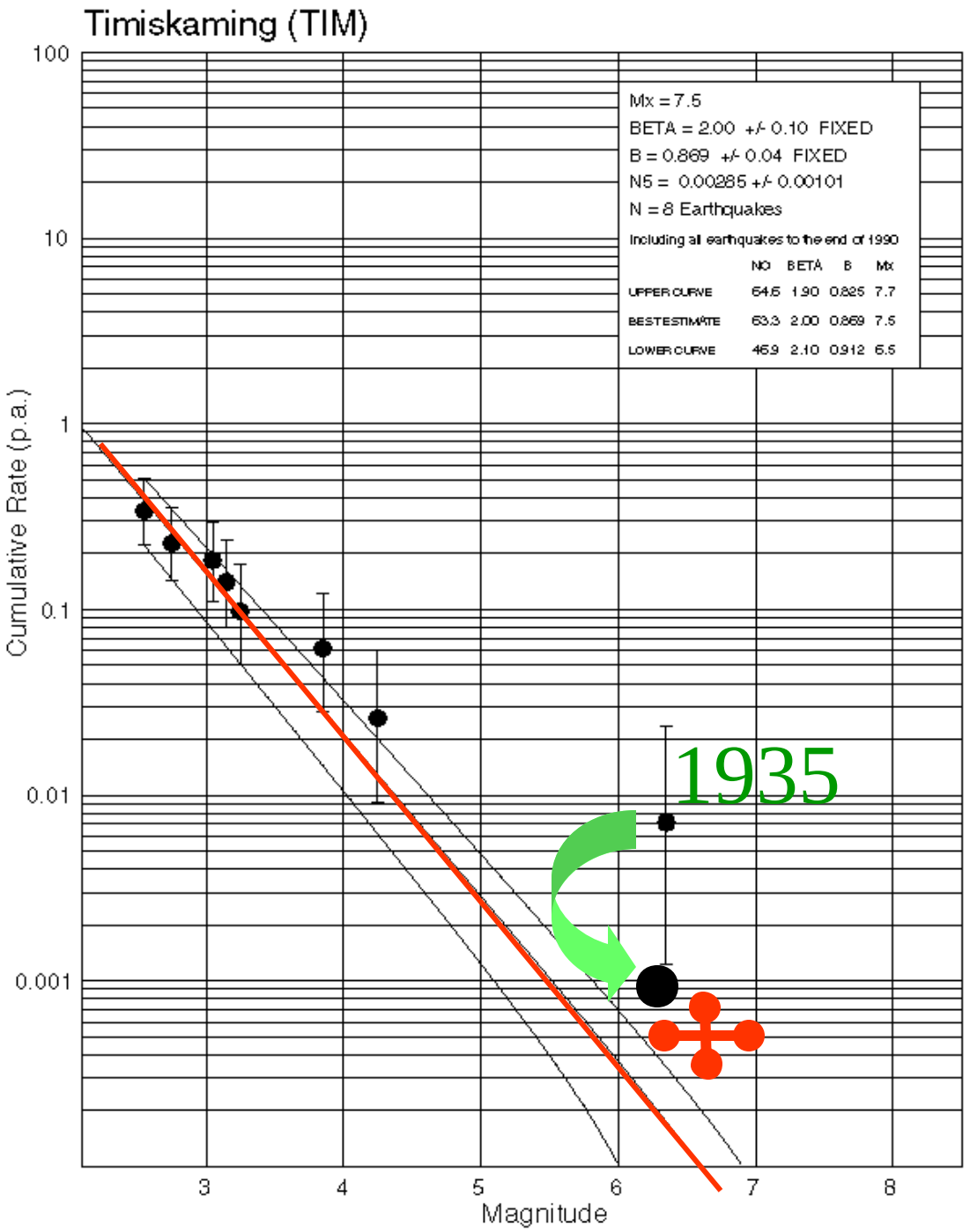

Sediment slumping Lac Tee, Doig 1999, CJES

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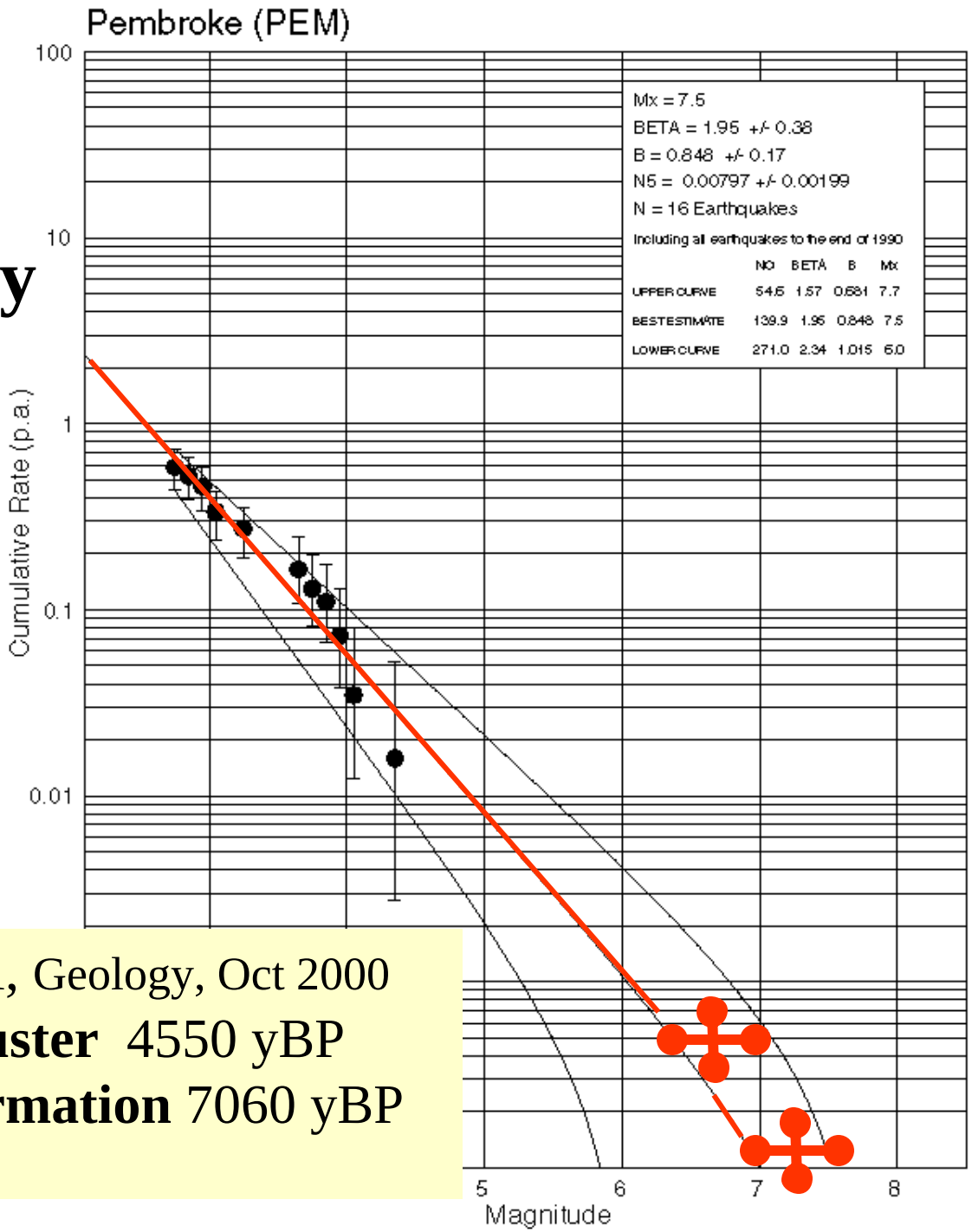
Paleoseismology

Earthquakes near Ottawa



Aylsworth et al, Geology, Oct 2000
landslide cluster 4550 yBP
sediment deformation 7060 yBP

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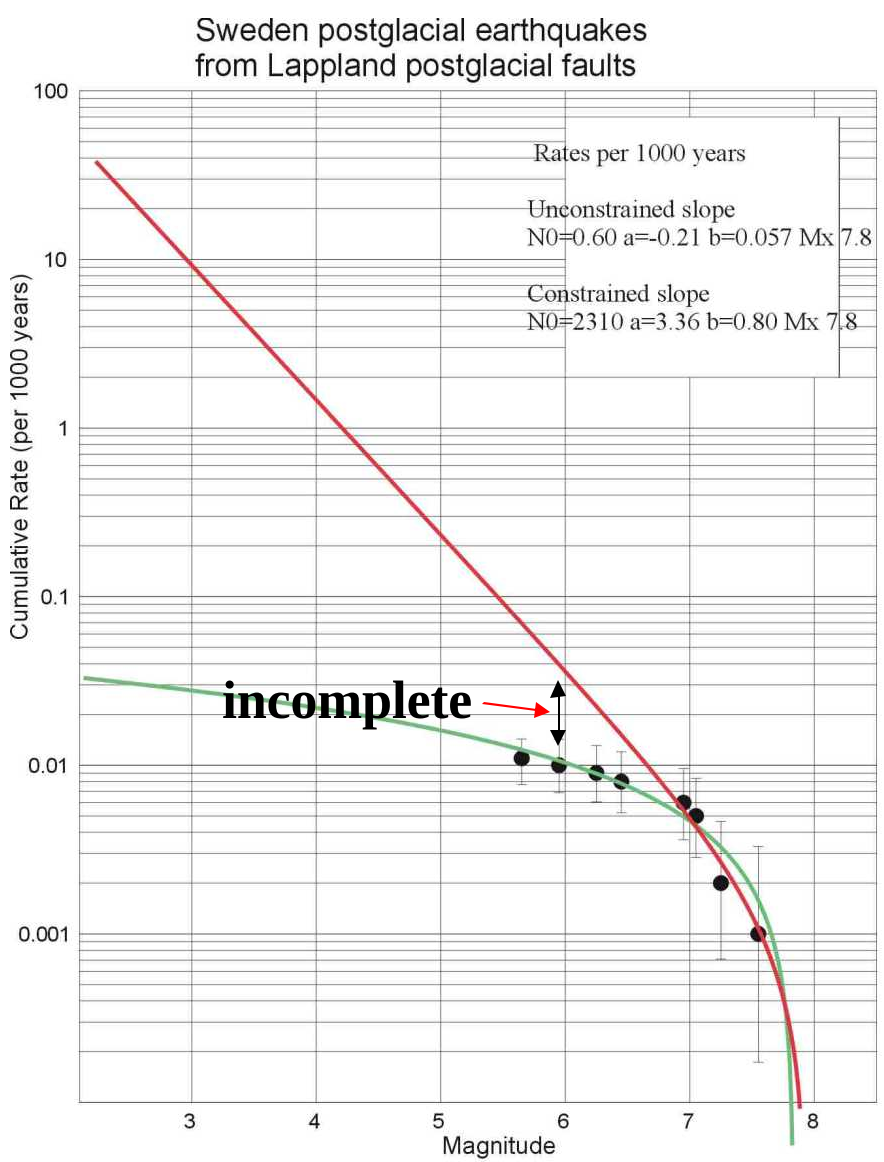
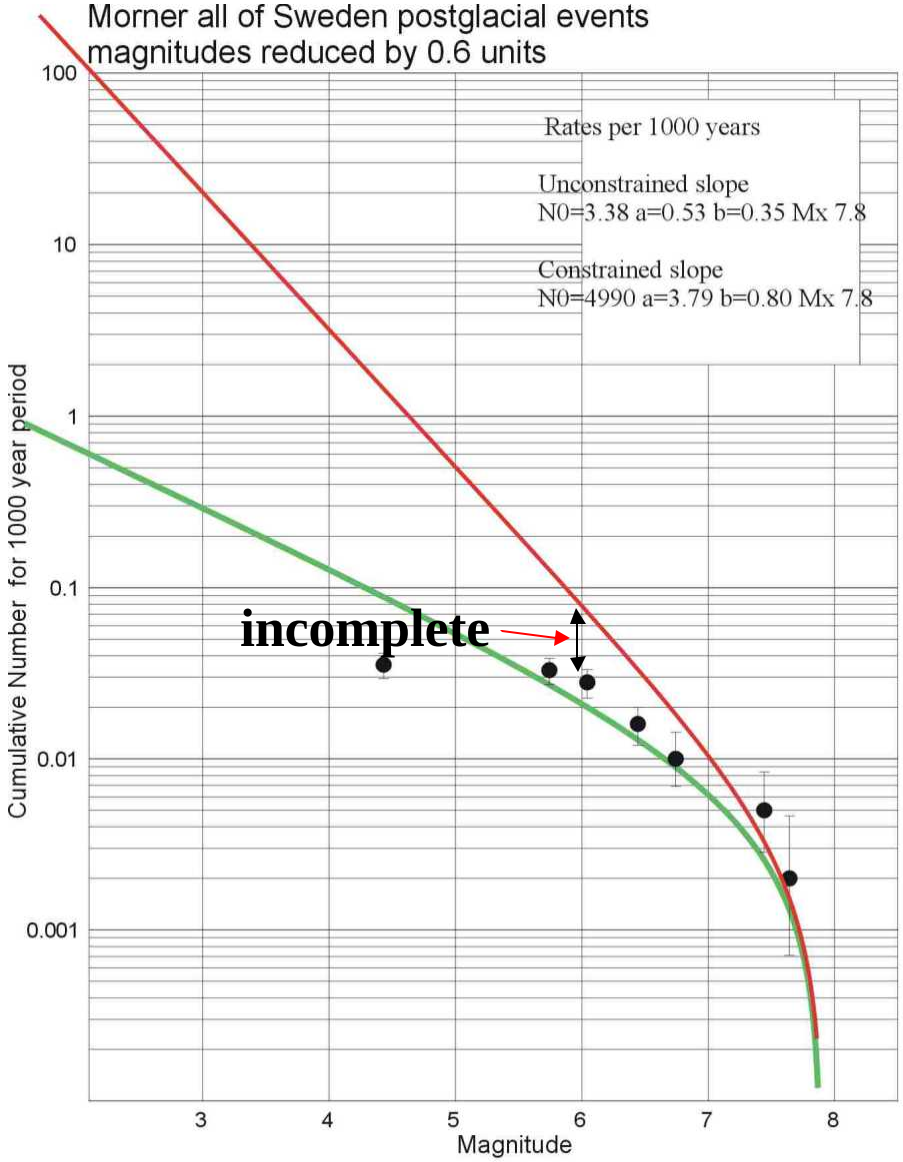
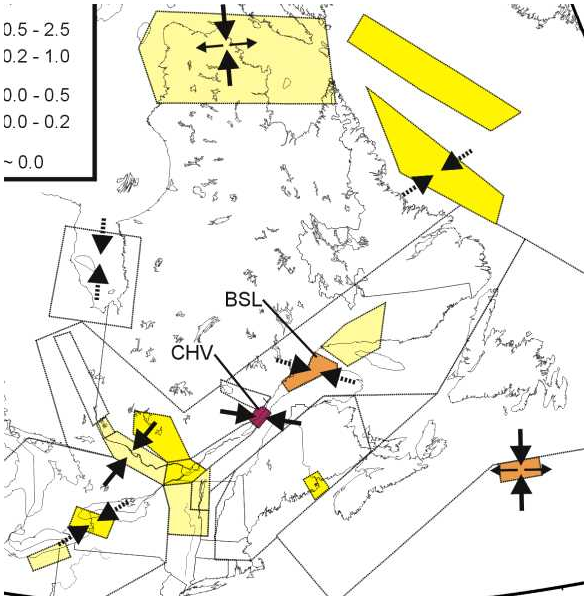
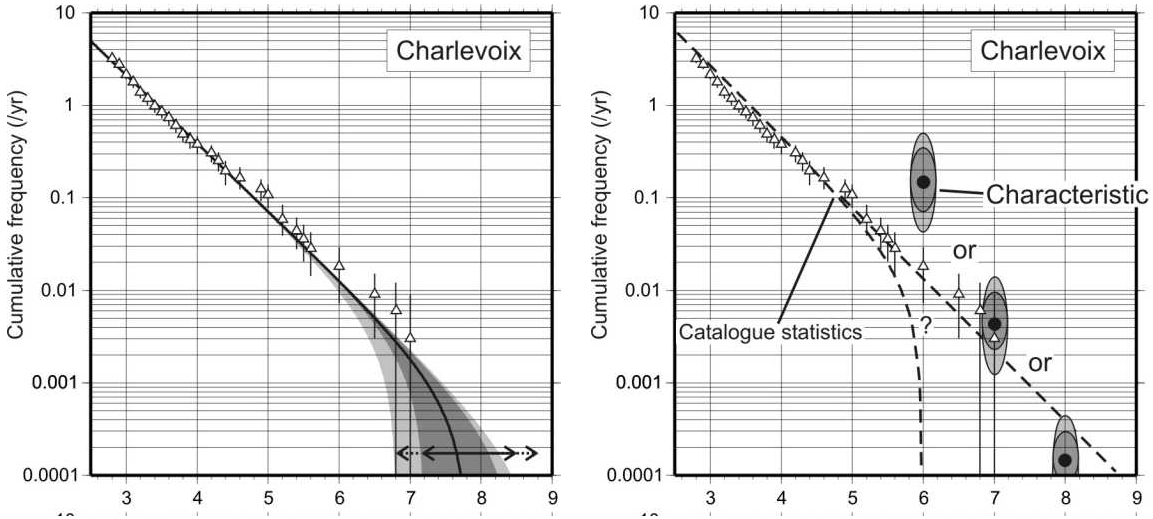
Scandinavian burst of deglacial earthquakes……..



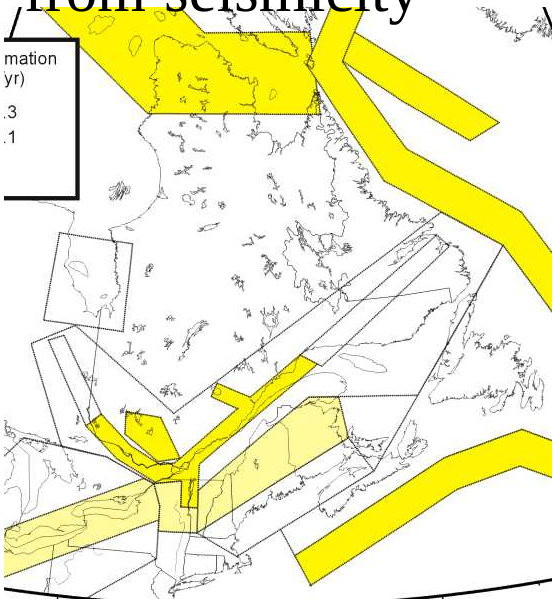




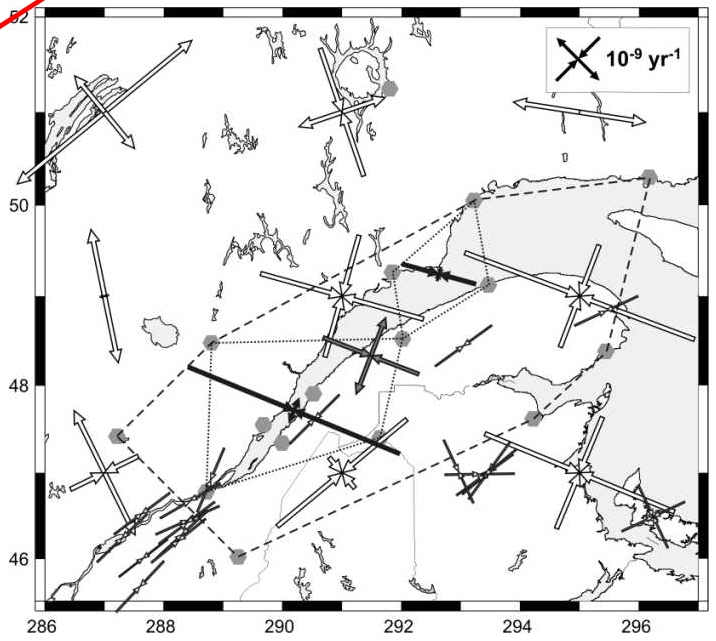


Implications

Deformation rate from seismicity



Measured deformation rate



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Mazzotti and Adams, 2005 Mazzotti et al, 2005 JGR

Modelling the Seismicity

Source “zones”

- USGS smoothed gridded seismicity

  Based on historical seismicity

  Large background zones (weight 0.2)

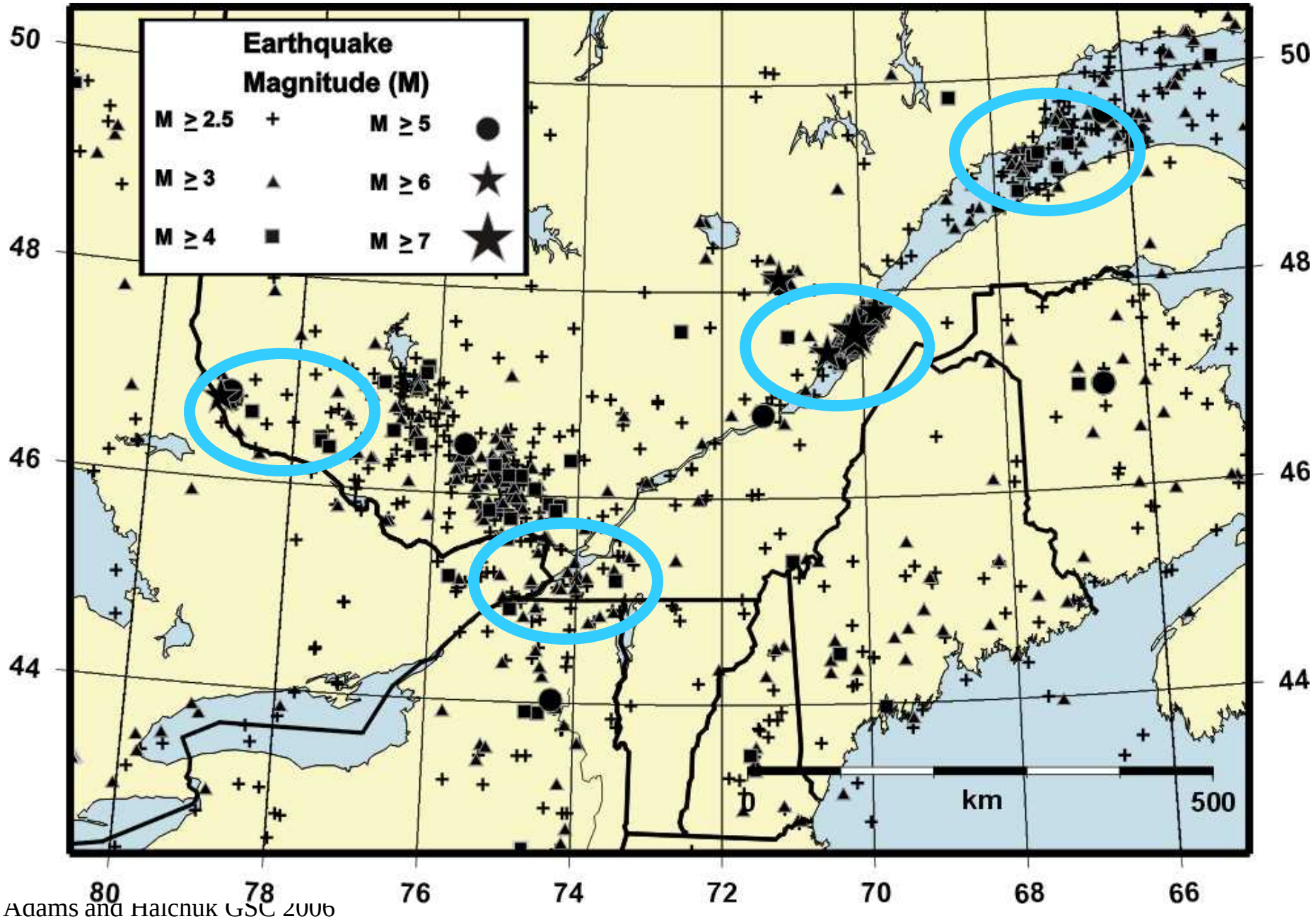
  Characteristic New Madrid and Charleston earthquakes

- GSC “Robust” method

  Cornell McGuire method, highest value of:
  Probabilistic Historical (H) model
  Probabilistic Regional (R) model
  Probabilistic Stable craton (F) model

Adams and Halchuk GSC 2006

Seismicity



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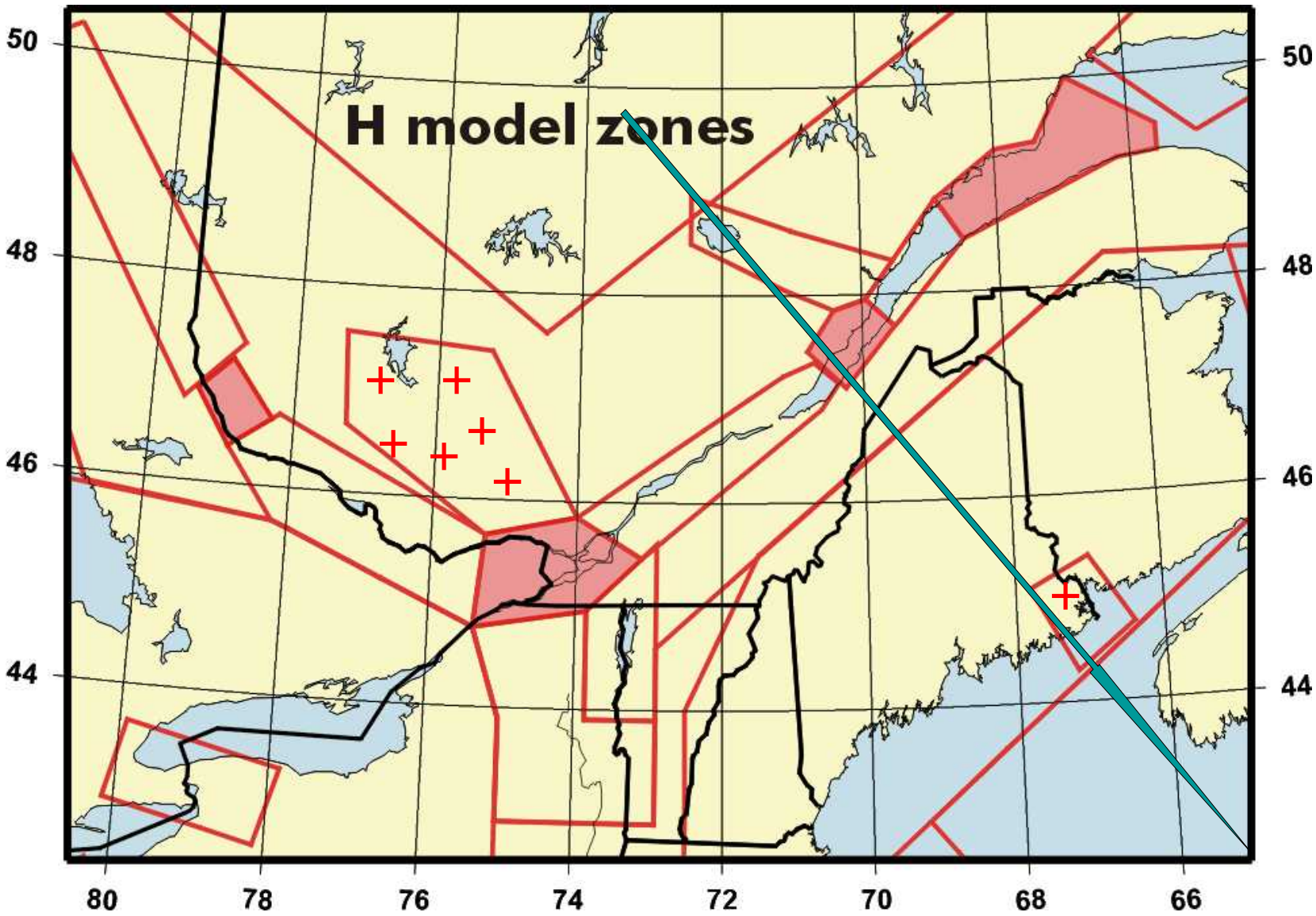
H = historical clusters



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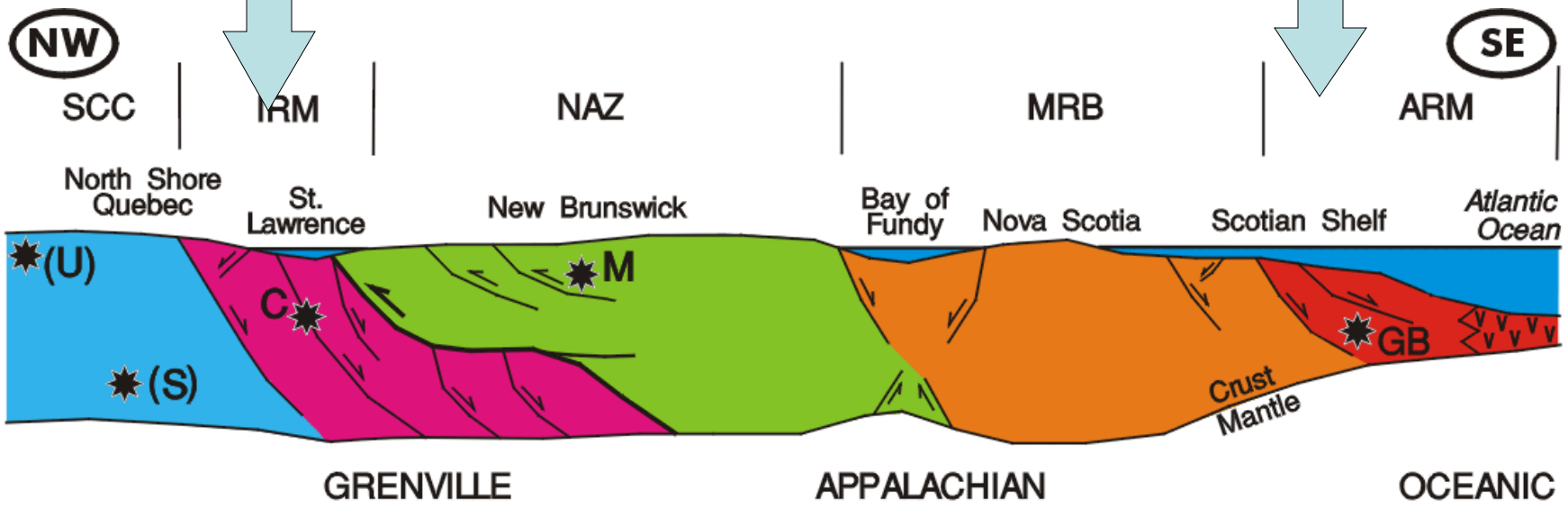
Ancient rifted margin

Modern rifted margin

Shield

Appalachians



Legend of representative earthquakes

U - 1989, 6.3, Ungava Peninsula, Quebec

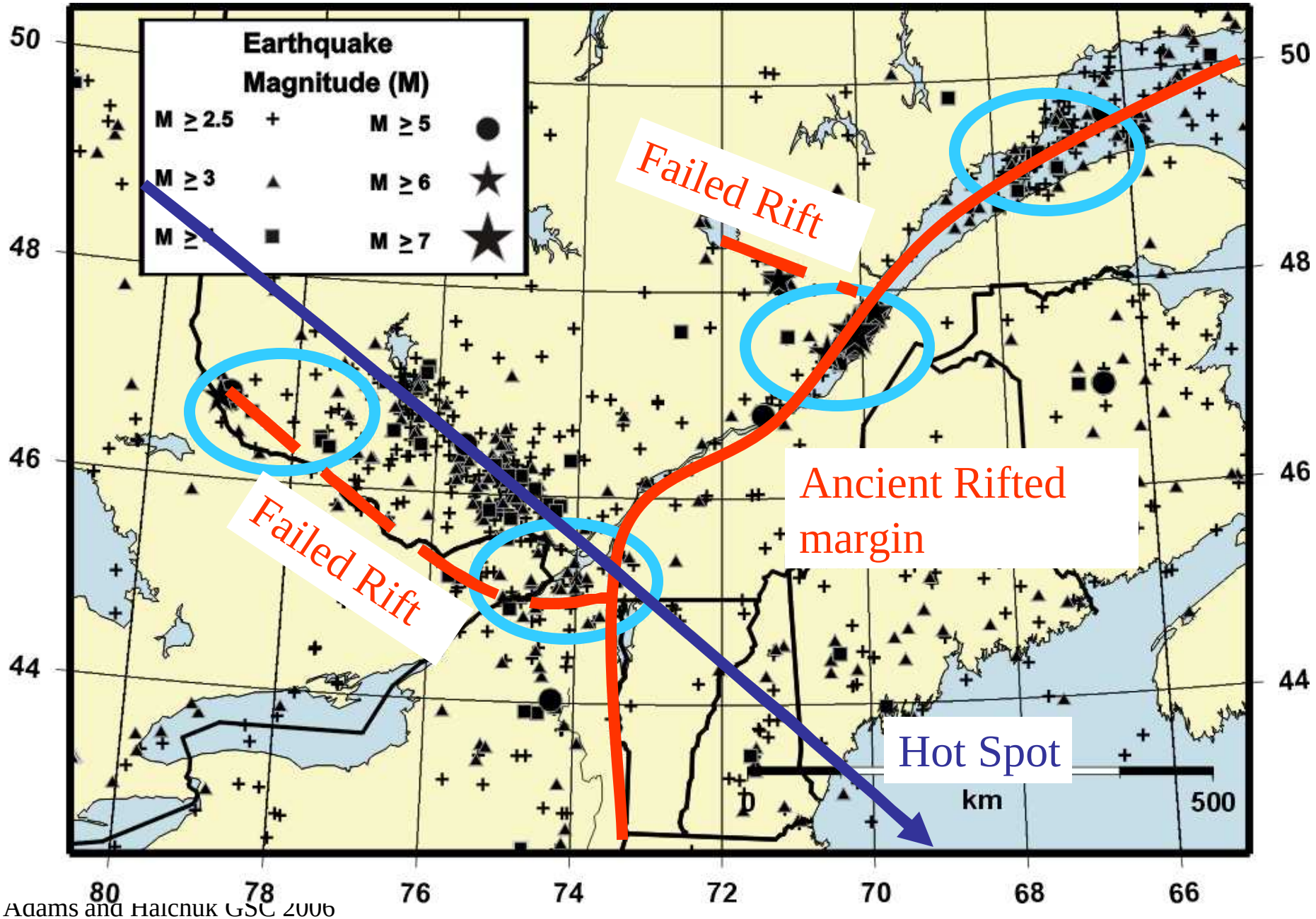
S - 1988, 5.9, Saguenay, Quebec

C - 1925, 6.2, Charlevoix-Kamouraska region, Quebec

M - 1982, 5.7 and 5.4, Miramichi region, New Brunswick

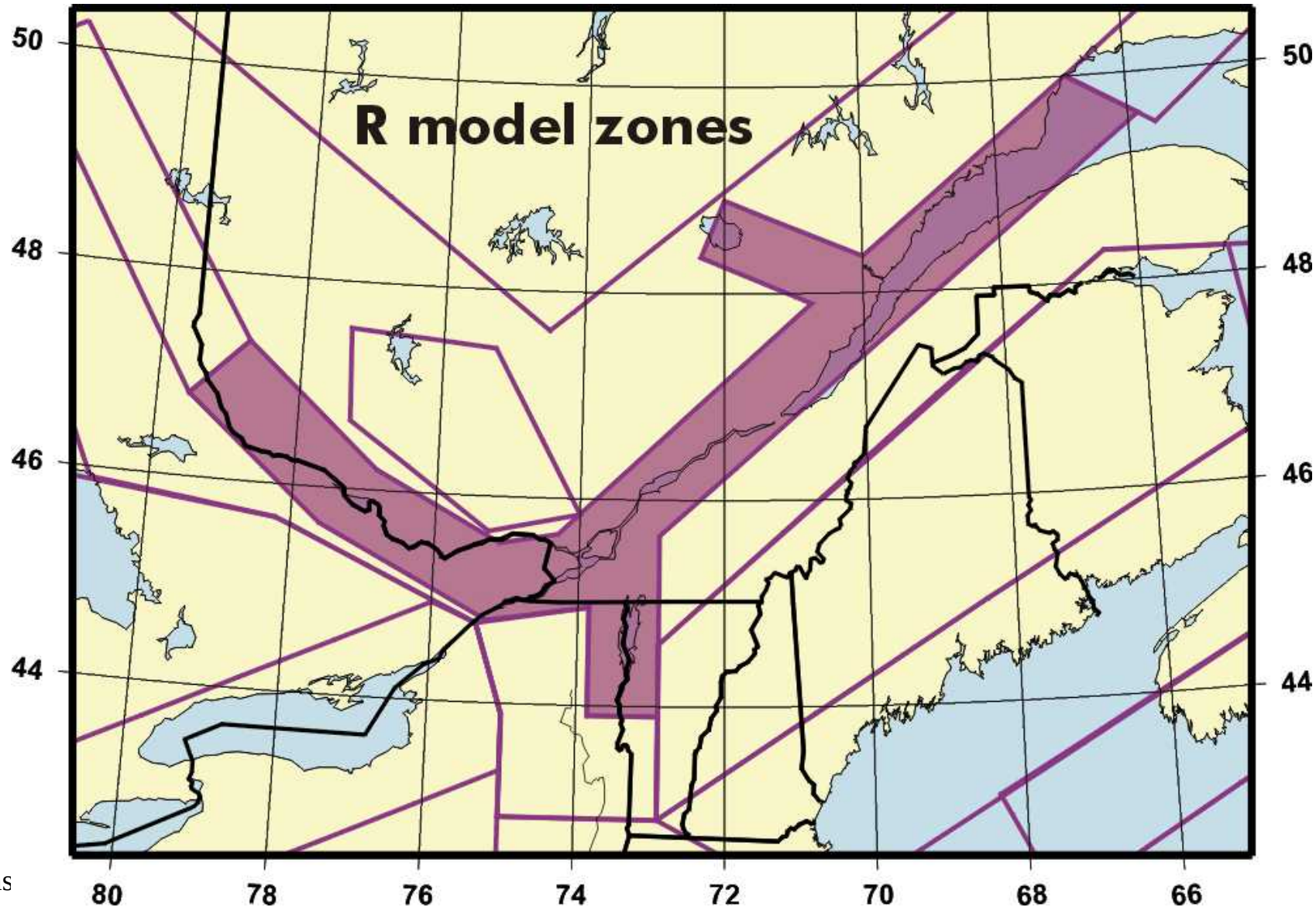
GB - 1929, 7.2, Grand Banks, Atlantic Ocean, south of Newfoundland

Seismicity

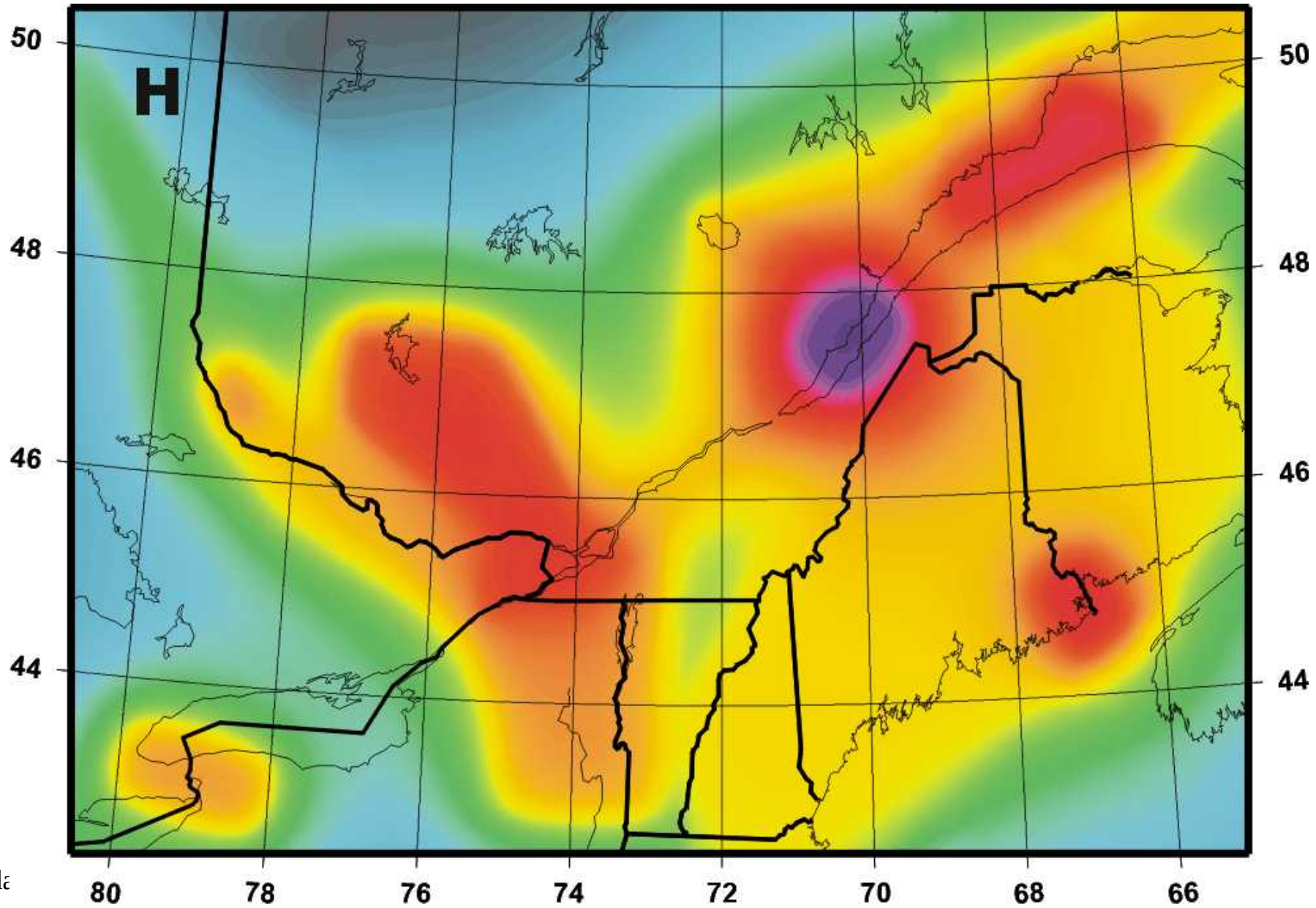


Adams and Halchuk GSC 2006

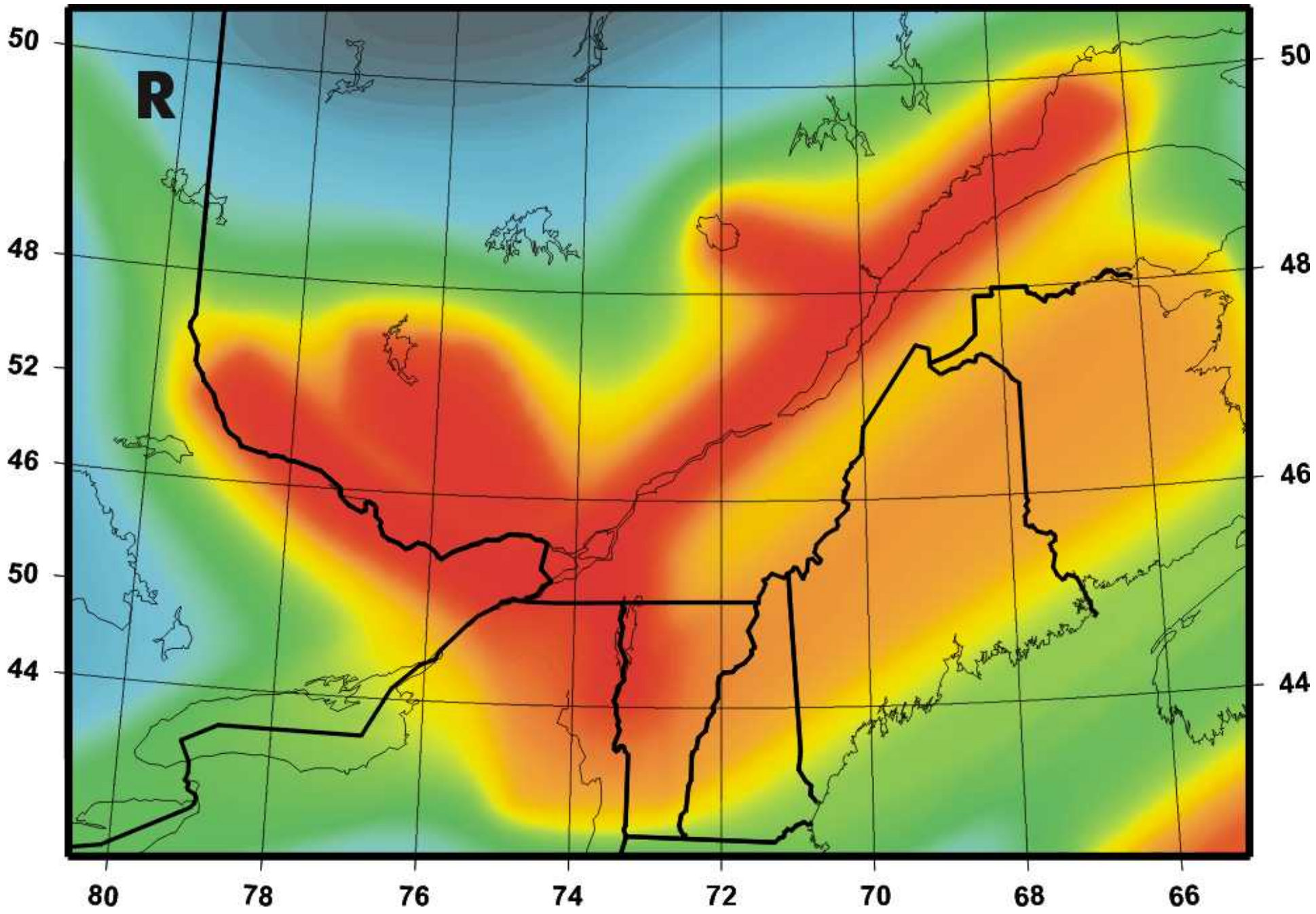
R = regional source



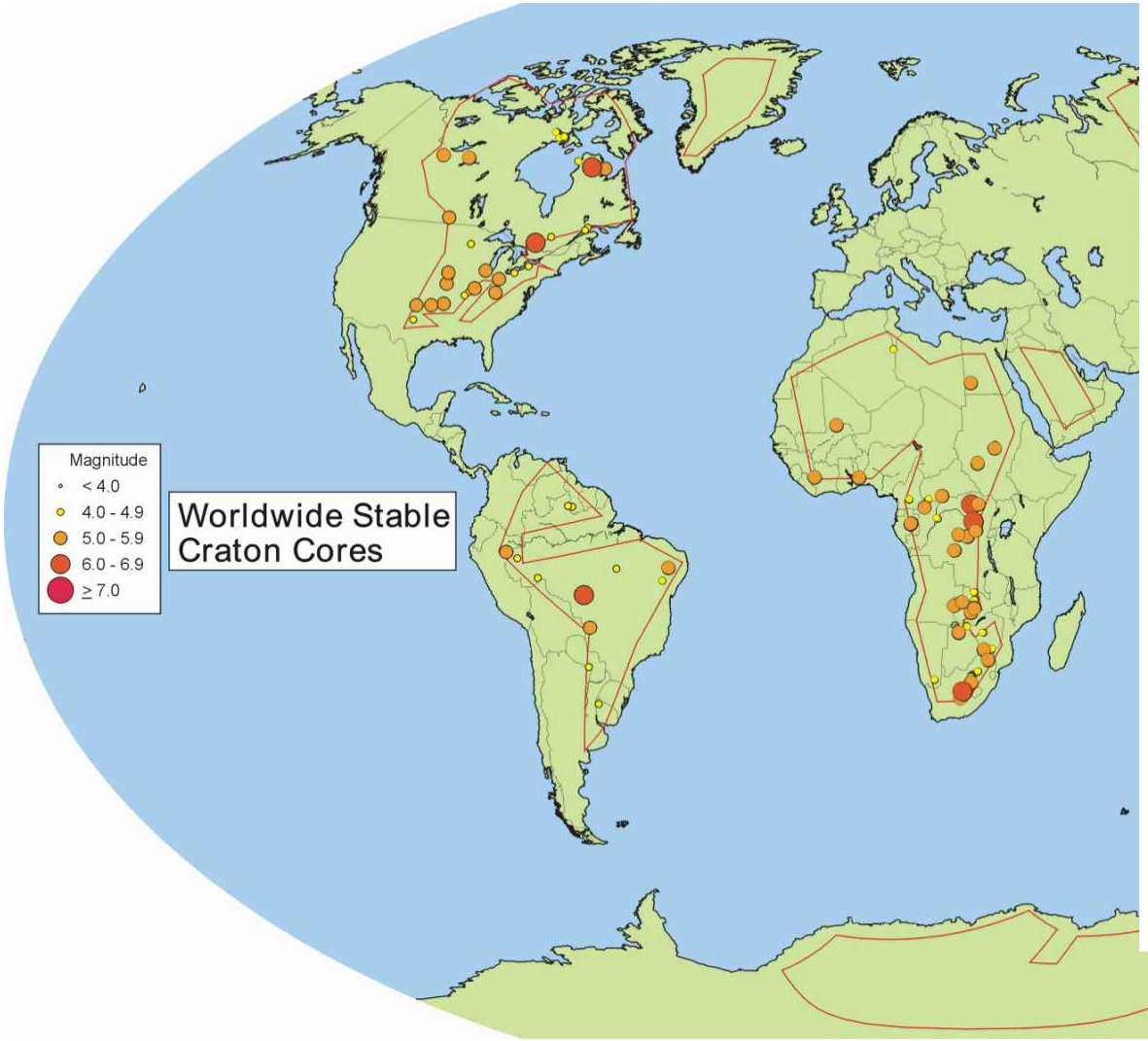
Adams

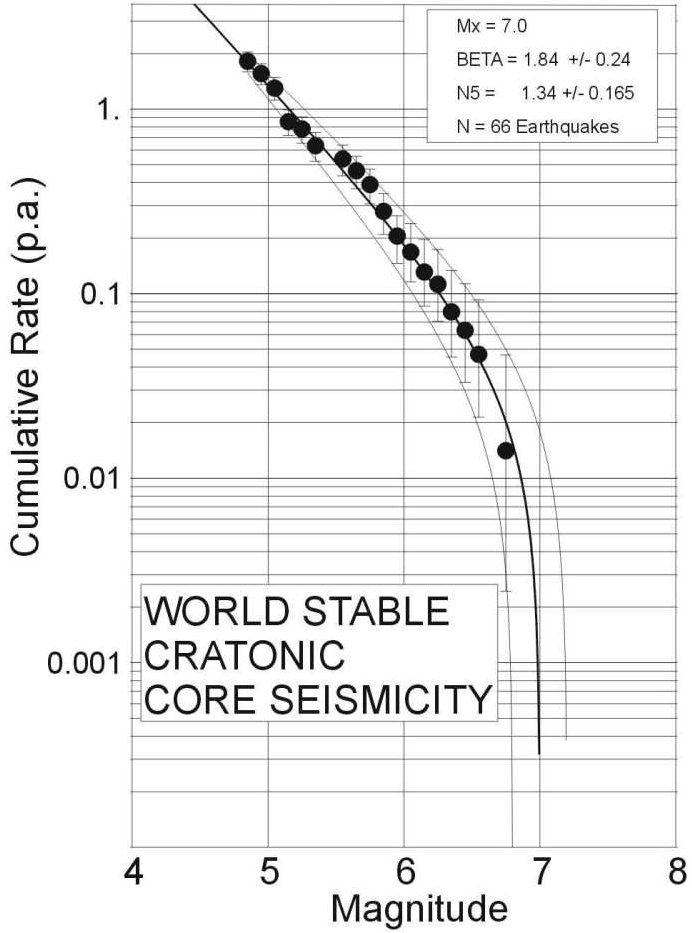


Ada


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

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



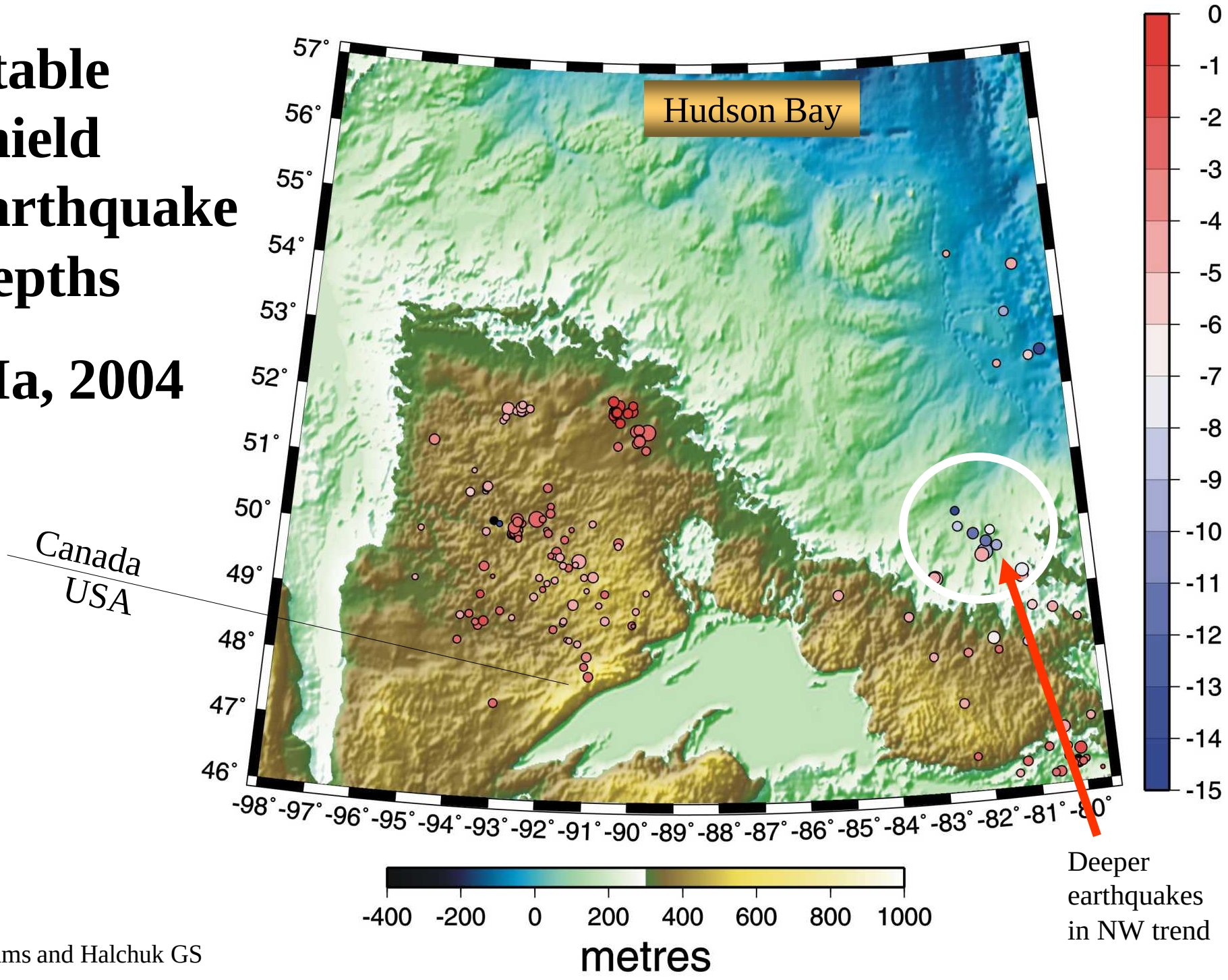


Fenton, Adams and Halchuk, GEGE, 2006

Adams and Halchuk GSC 2006

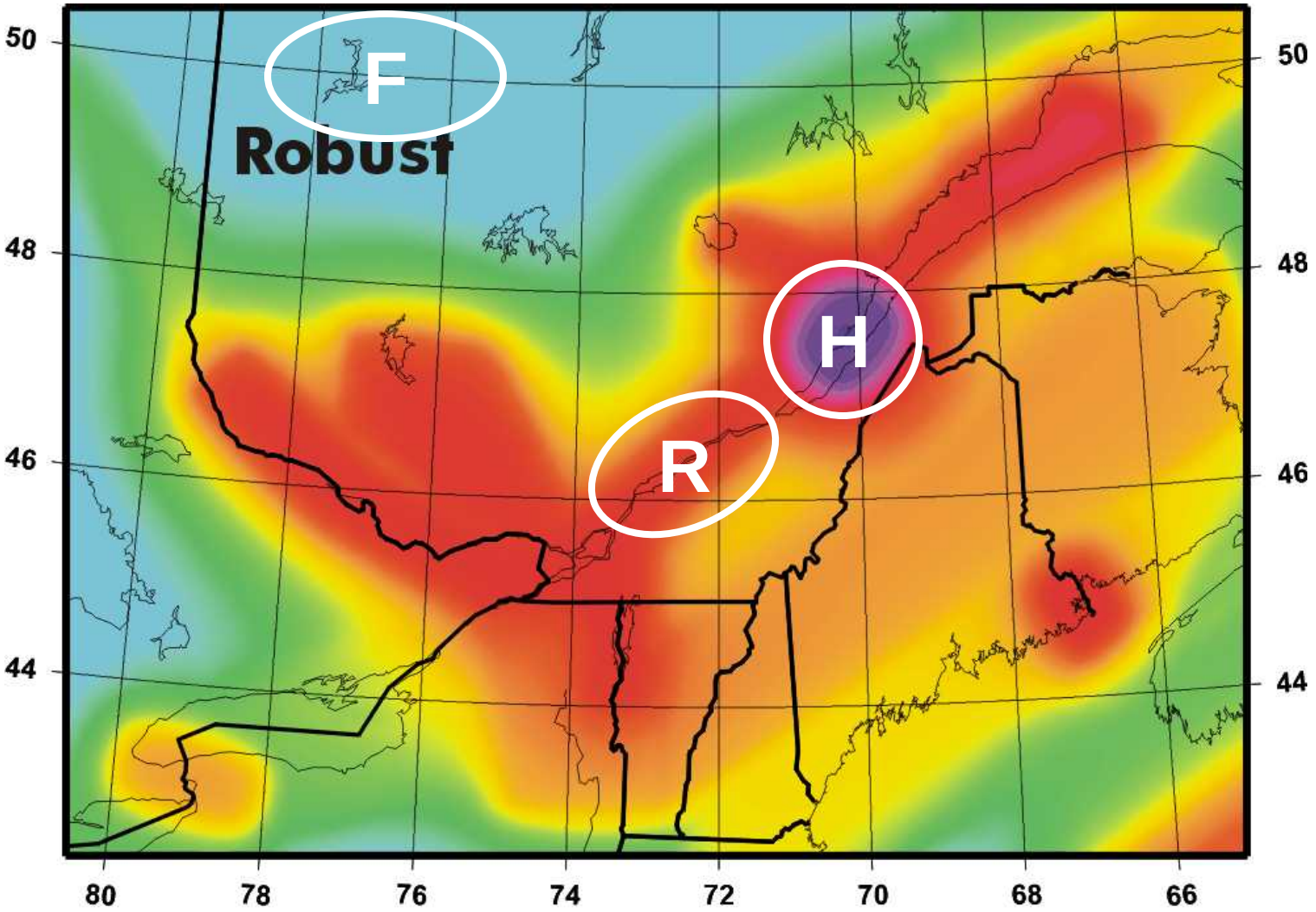
Stable shield earthquake depths

Ma, 2004



Adams and Halchuk GS

Robust Hazard



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Consequences for cross-border seismic hazard differences

Ground motion relations

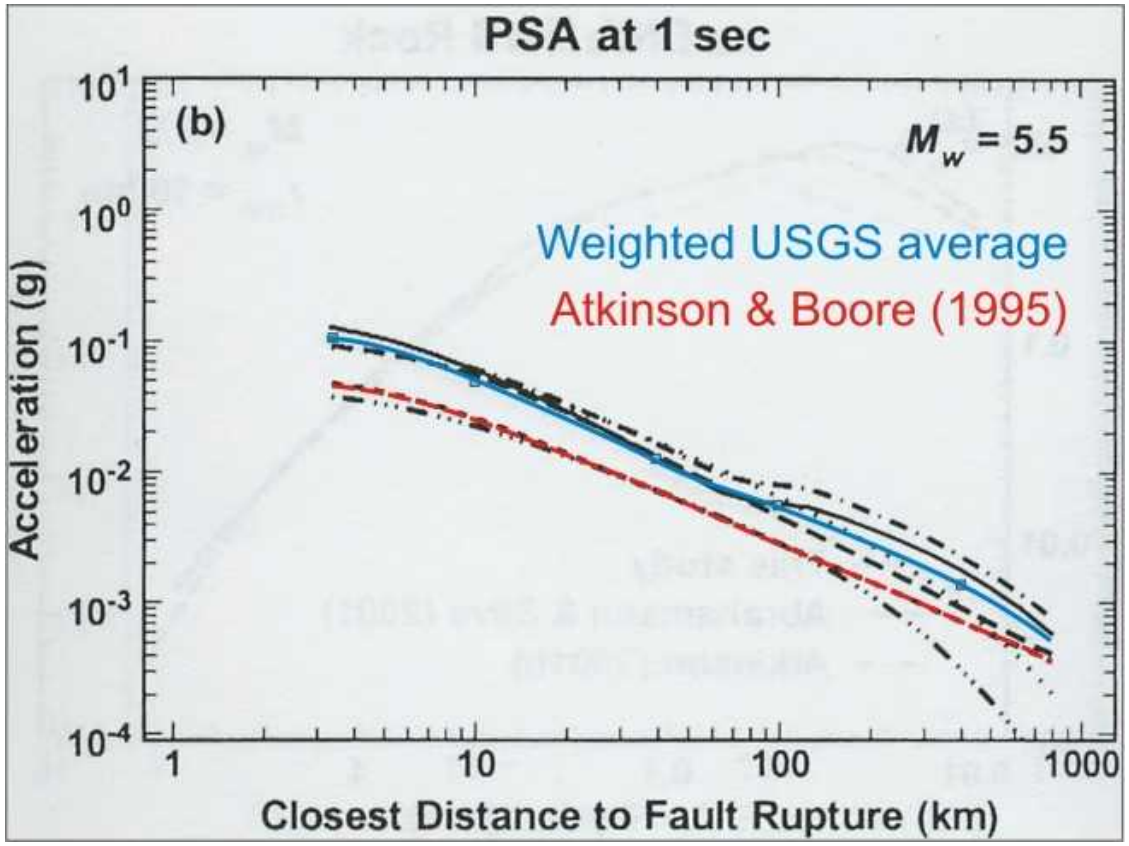
Eastern North America

- GSC – Atkinson & Boore 1995 (weight 1.0)
- USGS
  - Atkinson & Boore 1995 (weight 0.286)
  - Frankel et al. 1996 (weight 0.286)
  - Toro et al. 1997 (weight 0.286)
  - Campbell 2002 (weight 0.143)

  (Somerville et al. 2001 used only for characteristic New Madrid and Charleston events)

Ground motion relations

- PGA USGS weighted ground motion 10-30% lower than GSC Atkinson & Boore
- Sa(1.0) USGS almost double GSC
- Differences not as dramatic for larger magnitudes



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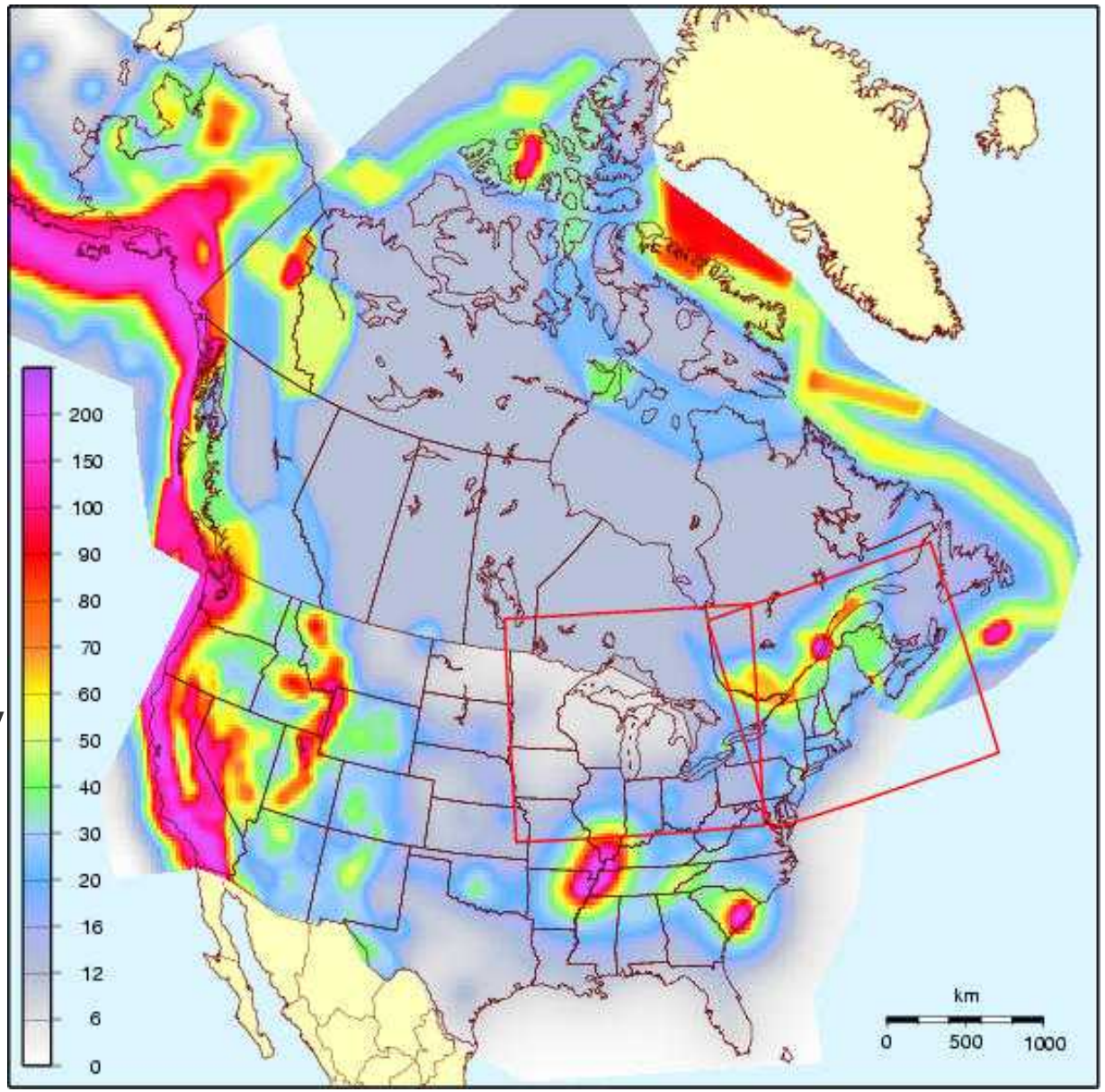
Combined North American seismic hazard map



- Sa(0.2) seconds
- 2%/50 year probability
- NBCC soil class C
  (US values adjusted)

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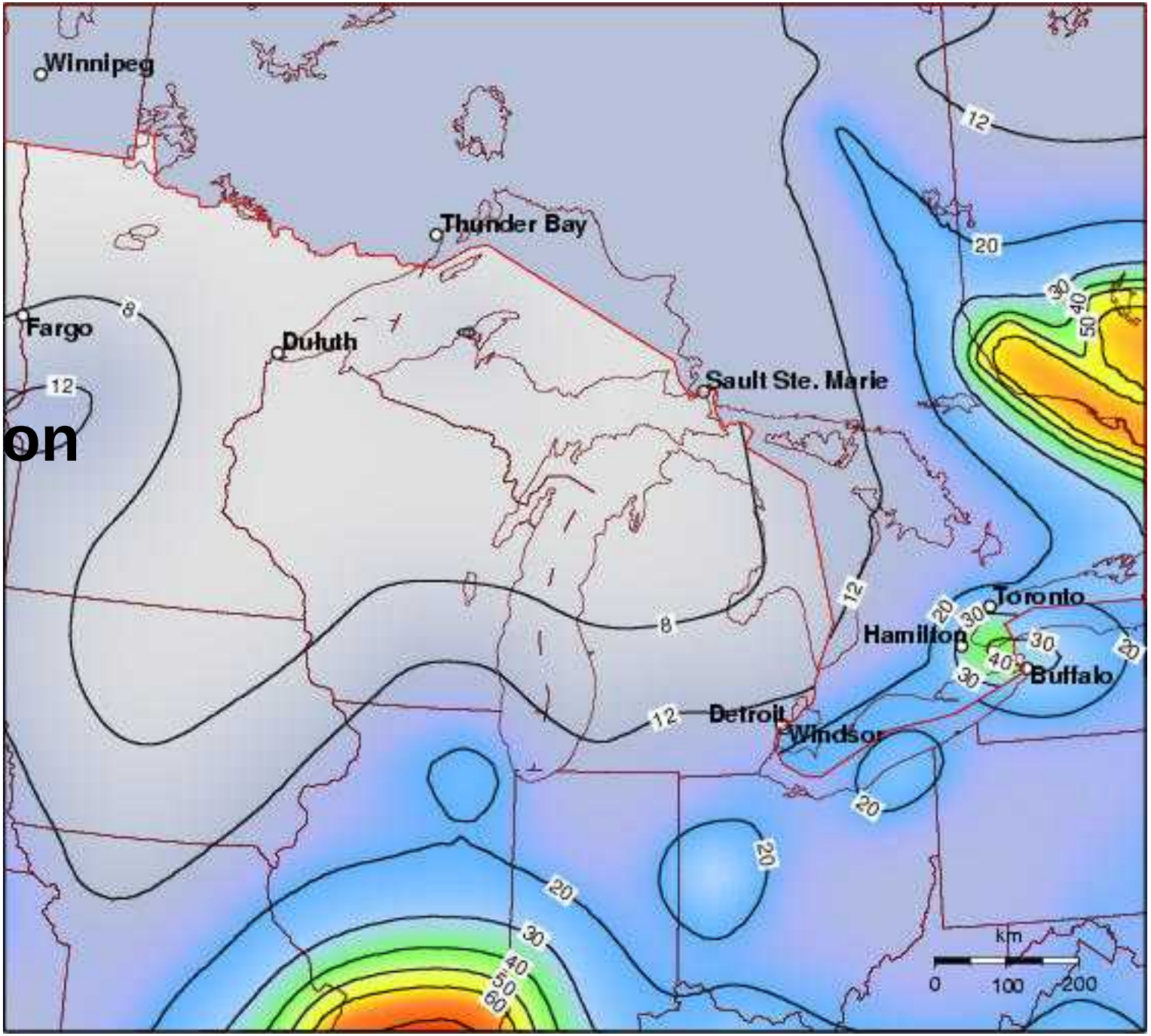
Central border region comparison



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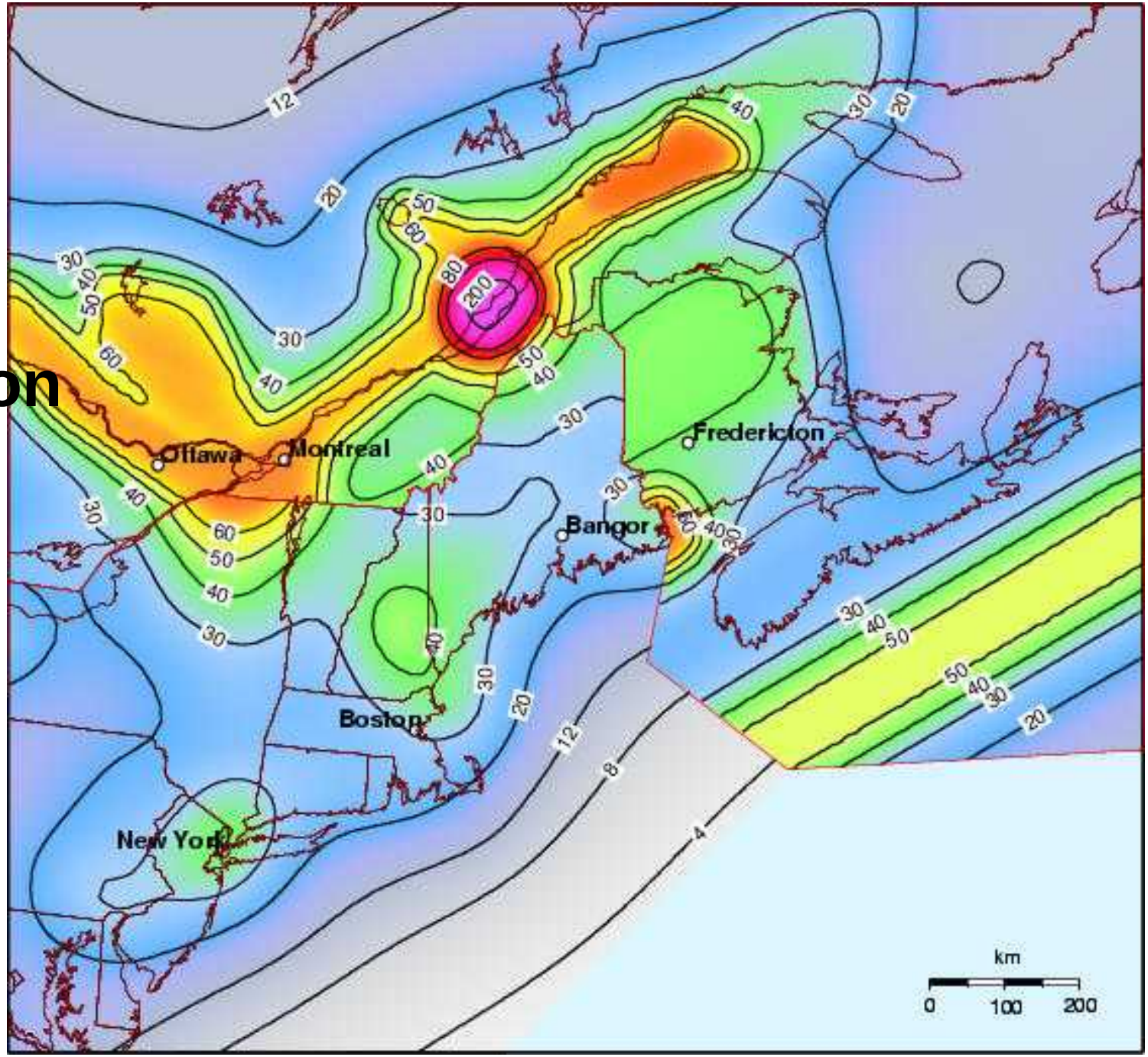
Eastern border region comparison



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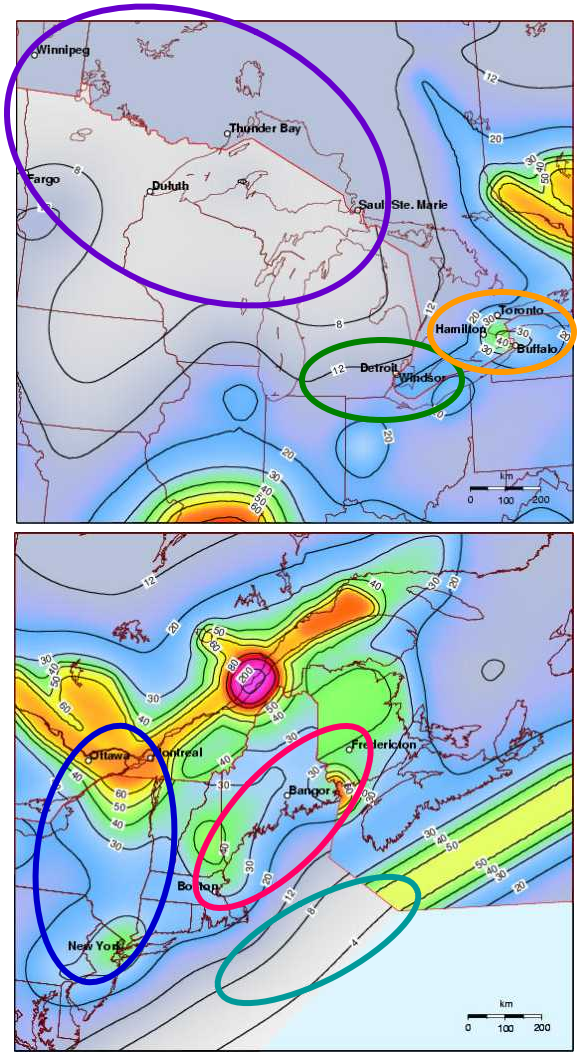
Canadian/USA cities comparison

	Sa (0.2)		Sa (1.0)	
Location	GSC	USGS	GSC	USGS
Winnipeg	0.12	0.05	0.023	0.017
Fargo	0.12	0.08	0.023	0.024
Duluth	0.12	0.06	0.023	0.020
Thunder Bay	0.12	0.06	0.023	0.017
Sault Ste. Marie	0.12	0.07	0.026	0.029
Detroit	0.17	0.13	0.039	0.051
Windsor	0.18	0.14	0.040	0.052
Hamilton	0.33	0.23	0.058	0.058
Toronto	0.26	0.22	0.055	0.060
Buffalo	0.40	0.30	0.069	0.067
Ottawa	0.66	0.53	0.13	0.12
Montreal	0.69	0.67	0.14	0.080
New York		0.39		0.080
Boston	0.28	0.31	0.060	0.078
Bangor	0.34	0.28	0.084	0.085
Fredericton	0.39	0.27	0.086	0.081



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Towards a smoother border crossing

- Is the soil class difference warranted?

GSC Soil Class C — USGS Soil Class B/C

- How do you determine long term hazard (2%/50 years)

GSC Robust H/R/F — USGS smoothed historical

- Which ground motion should you use?

GSC Atkinson Boore — USGS weighted average

- How certain are you of your uncertainties?

GSC median — USGS mean

Canadian seismic hazard timetable

driven by National Building Code cycle

- 4.5th Generation (improved current model)
  2006-?2009
- 5th Generation (might not be Cornell-McGuire)
  2006-2013

Adams and Halchuk GSC 2006