Mineral, VA, earthquake illustrates seismicity of a passive-aggressive margin

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8/23/2011 Washington Post

"Passive Aggressive behavior is a form of covert abuse. Covert abuse is subtle and veiled or disguised by actions that appear to be normal, at times loving and caring."

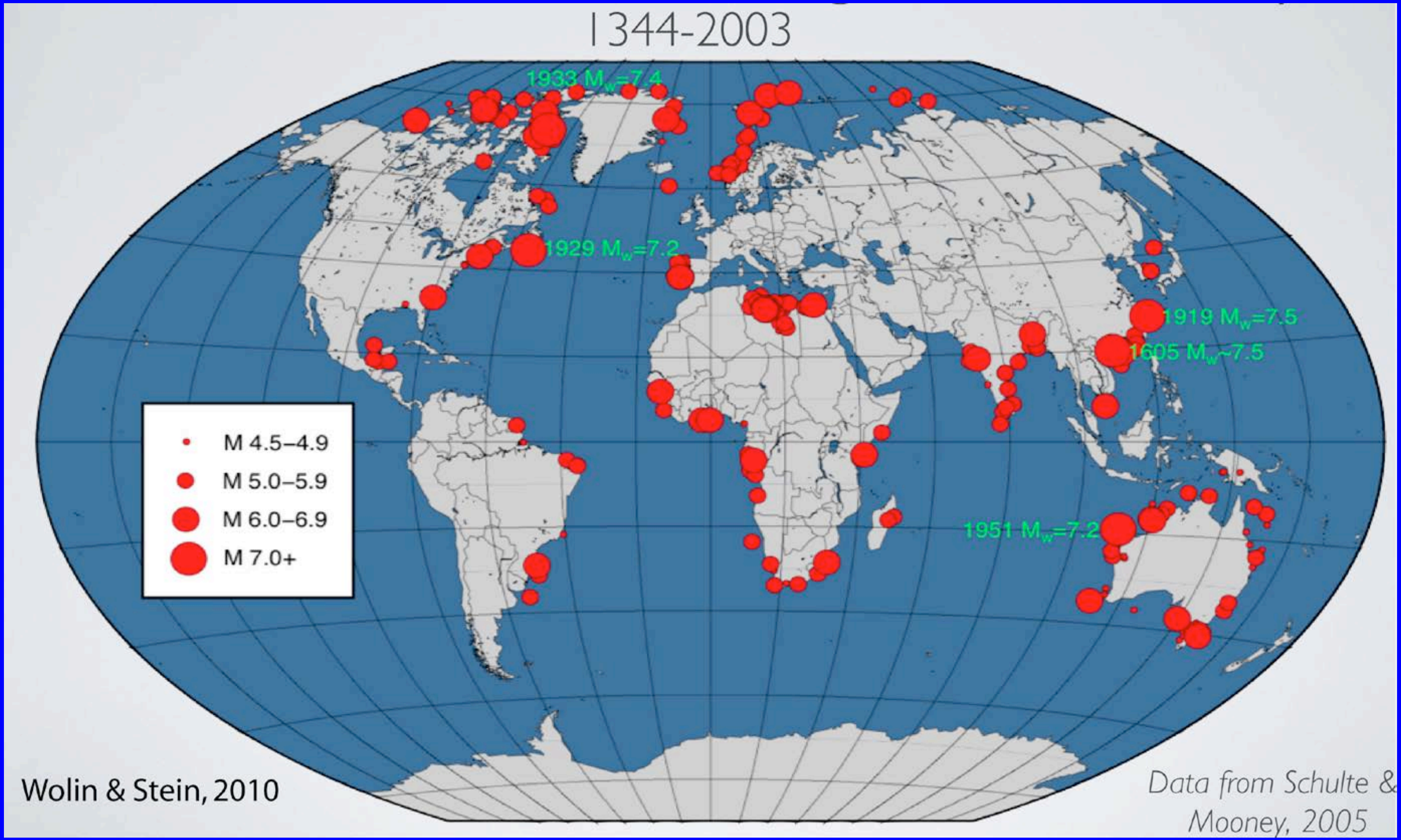
http://divorcesupport.about.com/od/abusiverelationships/a/Pass_Agg.htm

e.g., earthquakes in plate interior where idealized plate tectonics says they shouldn't happen

5.8 Virginia earthquake shakes East Coast, rattles residents

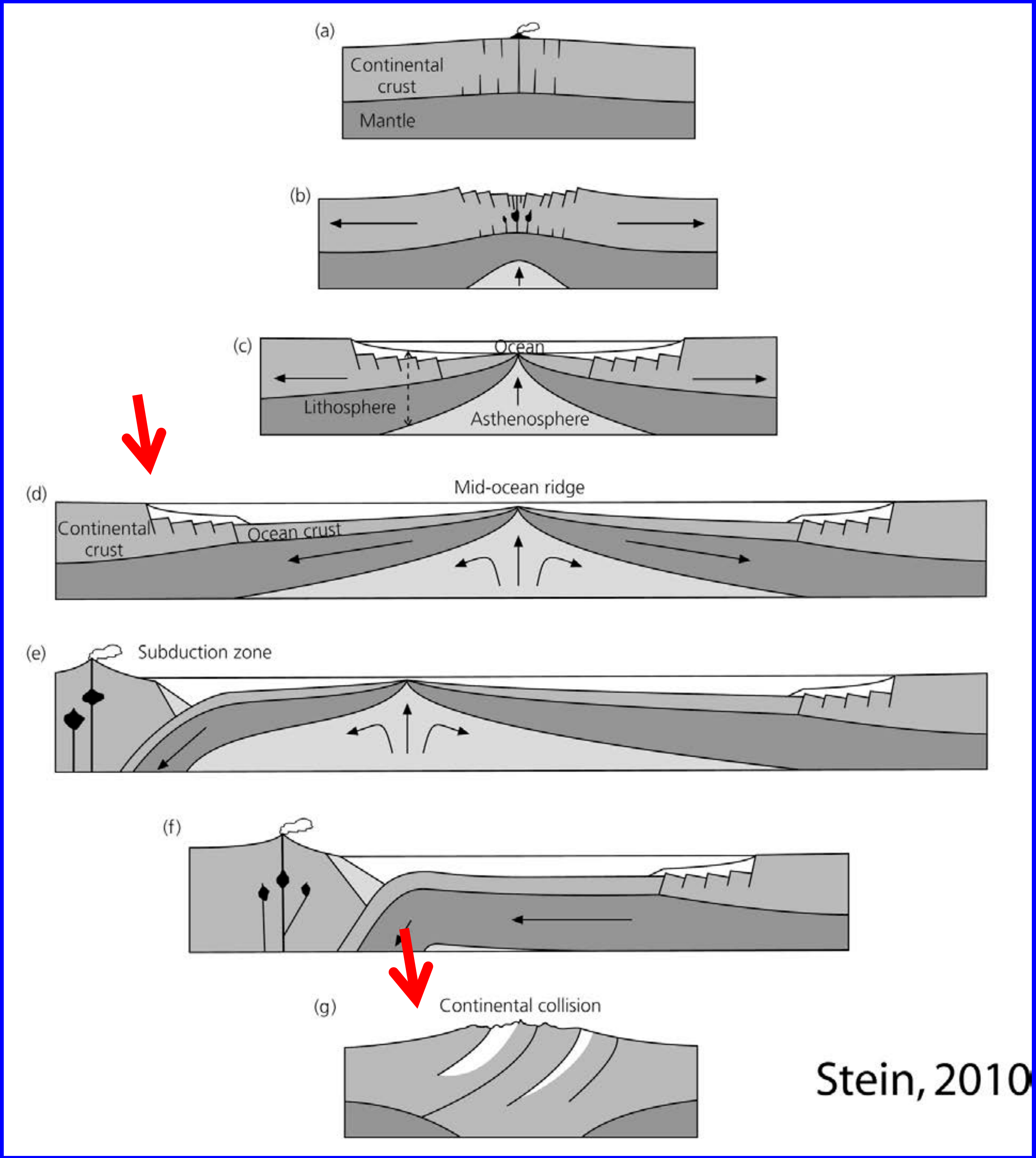
8/23/2011 Washington Post

Margins like ENAs are "passive" in not being plate boundaries, but are seismically active



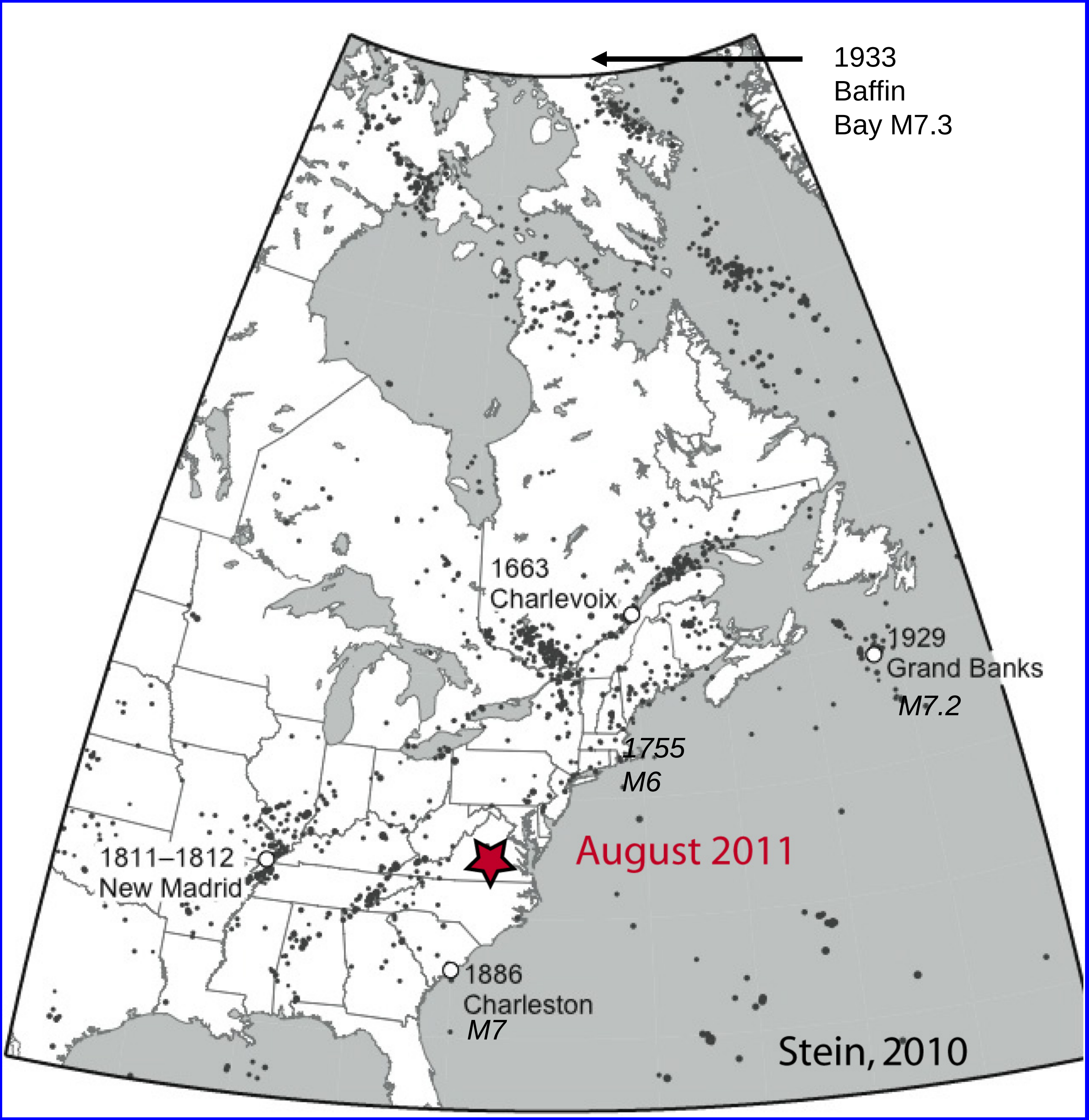
"Nearly all stable masses exhibit marginal features which are seismically active." Gutenberg and Richter (1954)

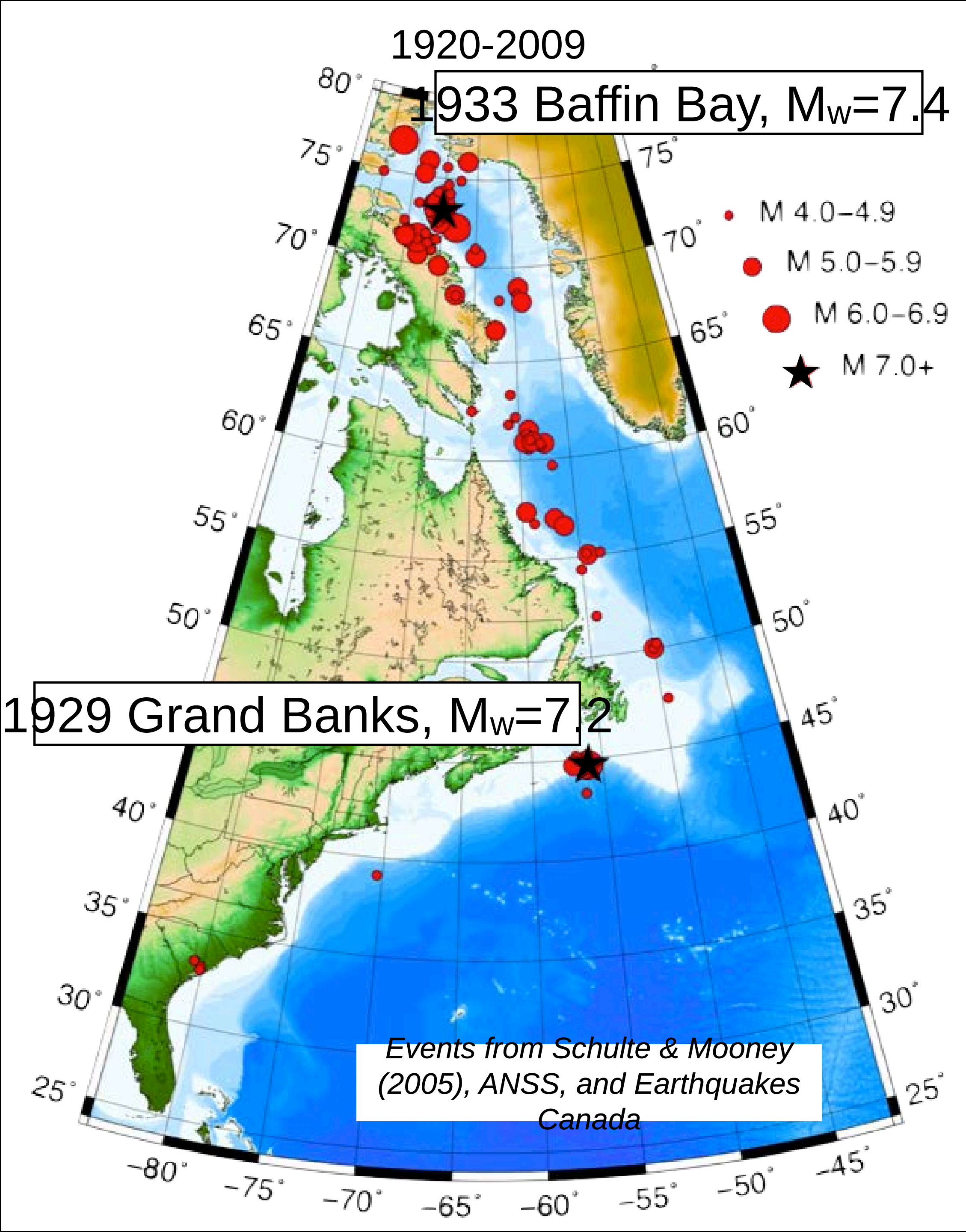
Many passive margin earthquakes presumably reactivate faults remaining from ocean closing and rifting



2011 VA quake is generally part of ENA's most active seismic zone

The passive continental margin has events up to M7

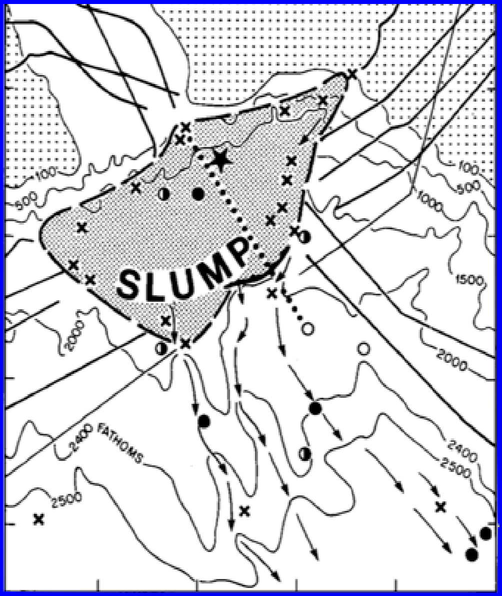




- Some passive margin earthquakes generate large landslides and/or tsunamis
- Can large landslides occur without a seismic trigger?
- Important for evaluating seismic & tsunami hazards

1929 Grand Banks Mw 7.2

Enormous (~100 km^3) submarine landslide cut trans-Atlantic telegraph cables & caused tsunami responsible for 27 deaths



Earthquakes Canada; Hasegawa & Kanamori (1987)

Source studies (Hasegawa & Kanamori (1987), Bent (1995)) differ as to whether landslide triggered by earthquake

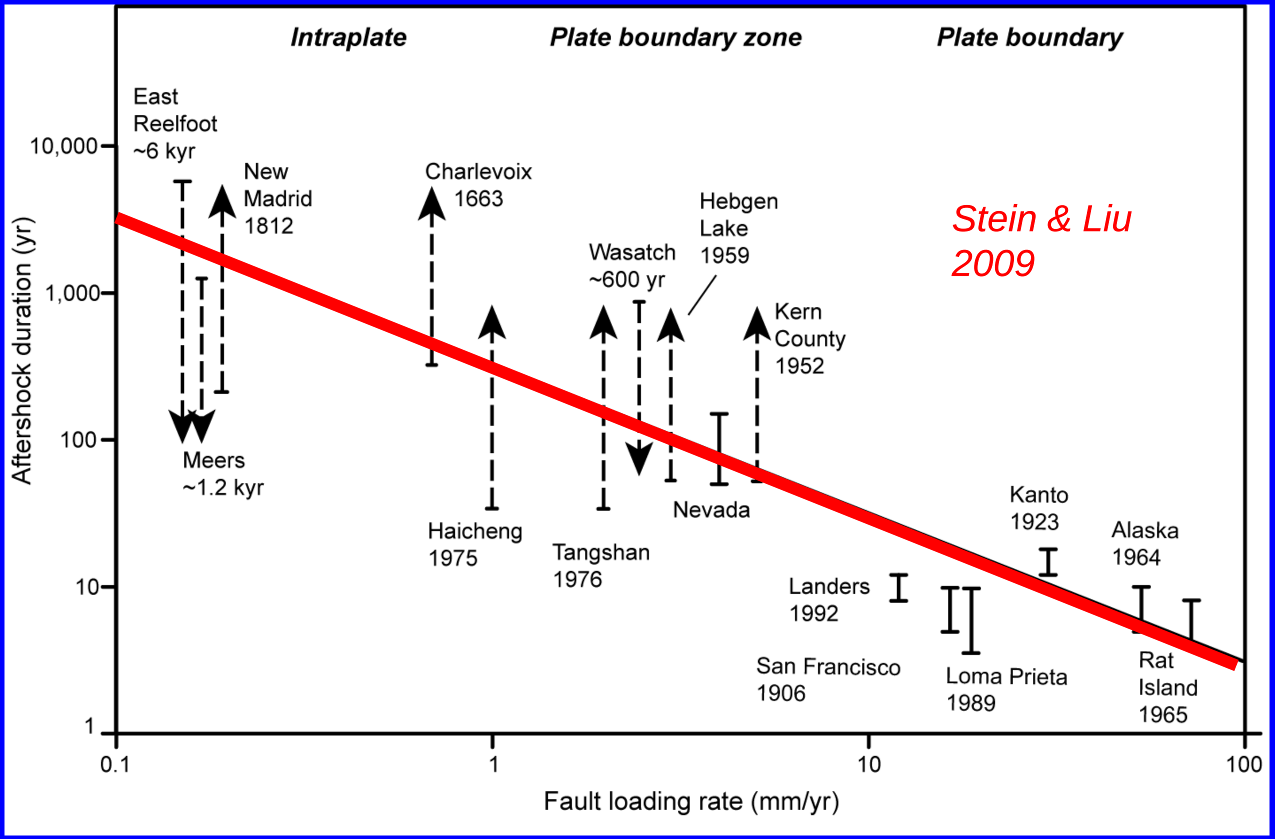
Other approach: consider aftershocks

Rate-state friction predicts aftershock duration α 1/loading rate

Plate boundary faults quickly reloaded by steady plate motion after large earthquake

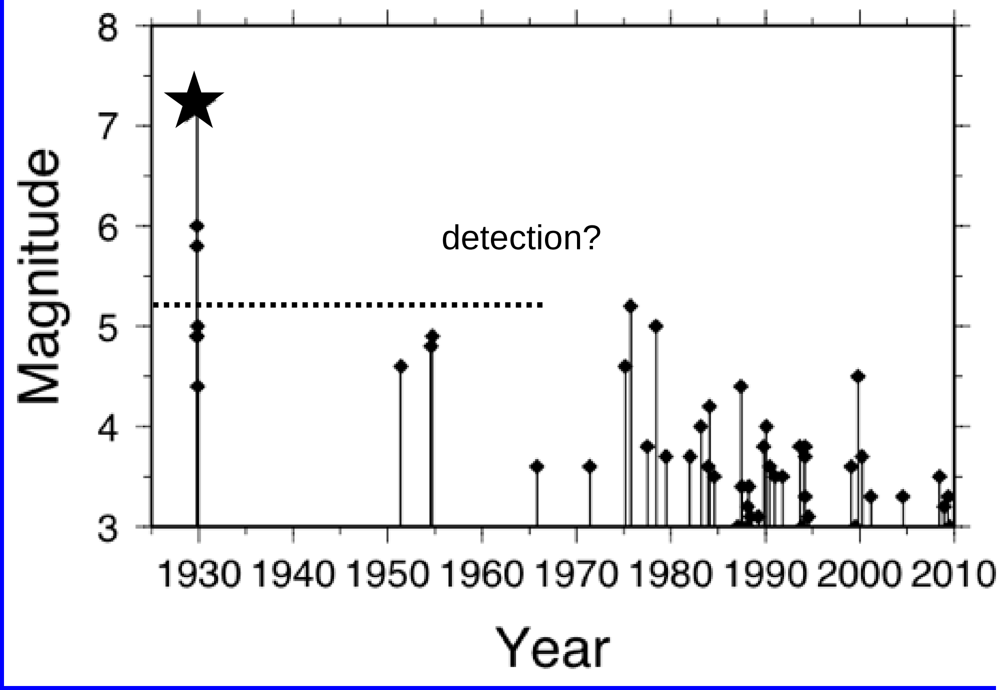
Faults in continents reloaded much more slowly, so aftershocks continue much longer

Passive margin may be similar

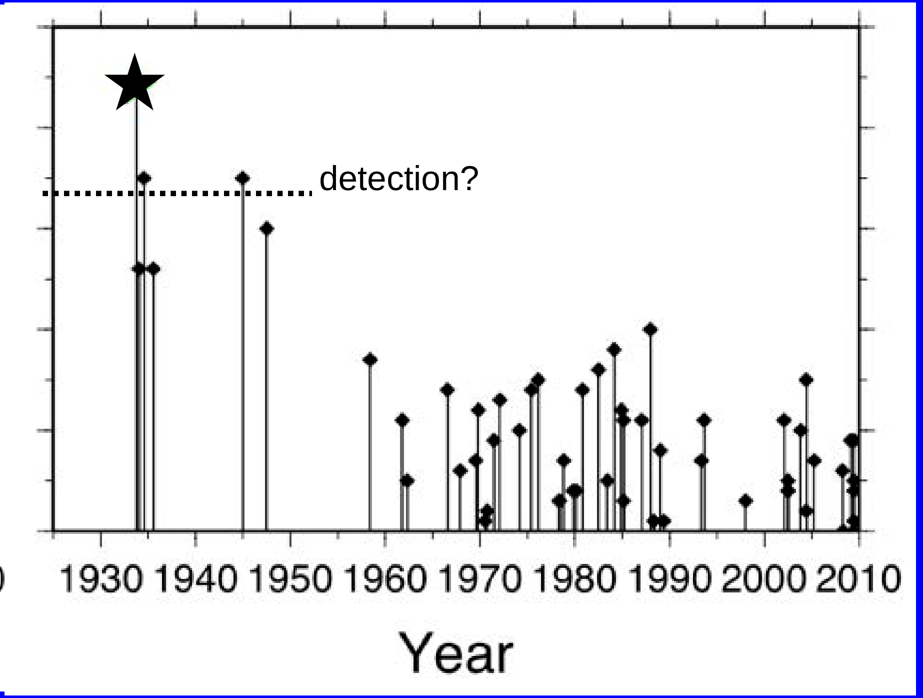


Despite challenge of non-uniform detection, aftershocks of both earthquakes continue for decades, suggesting tectonic earthquakes rather than landslides

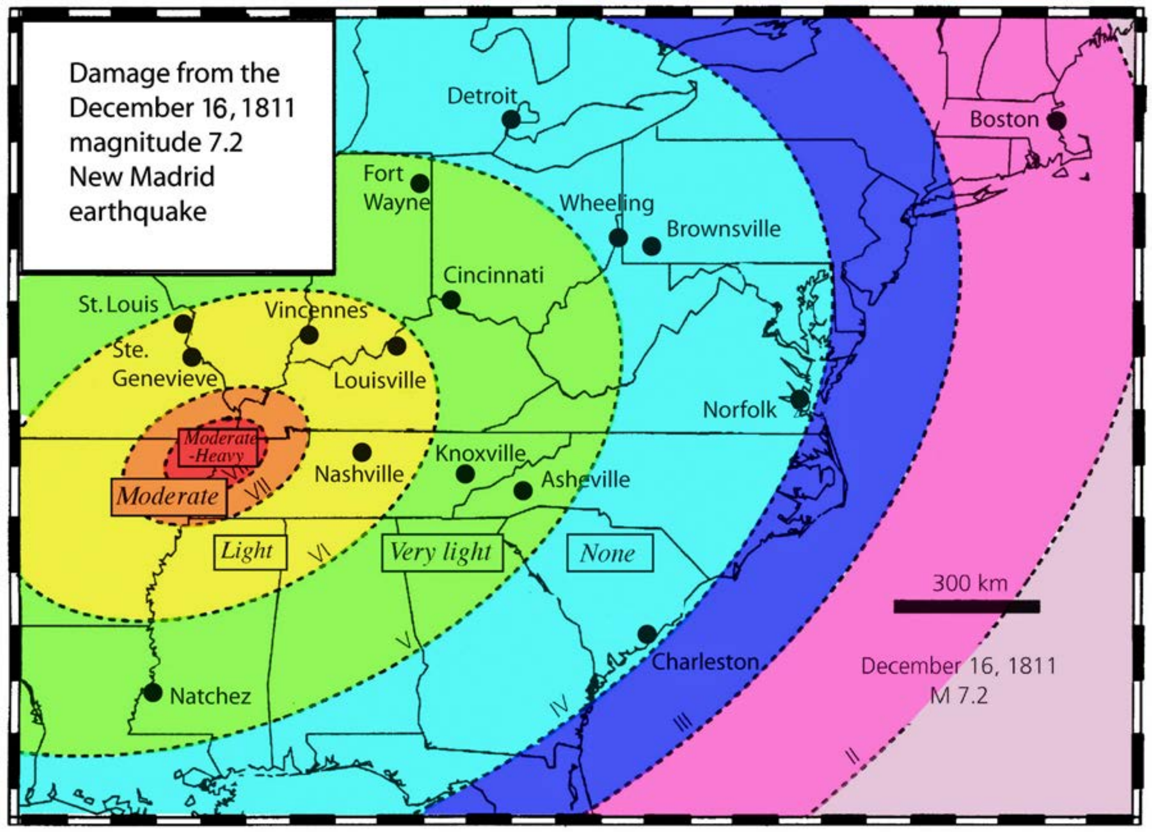
Grand Banks



Baffin Bay



Wolin & Stein, 2010



1929 shaking similar to 1811-12 New Madrid

Propagation in ENAM crust

Similar magnitude

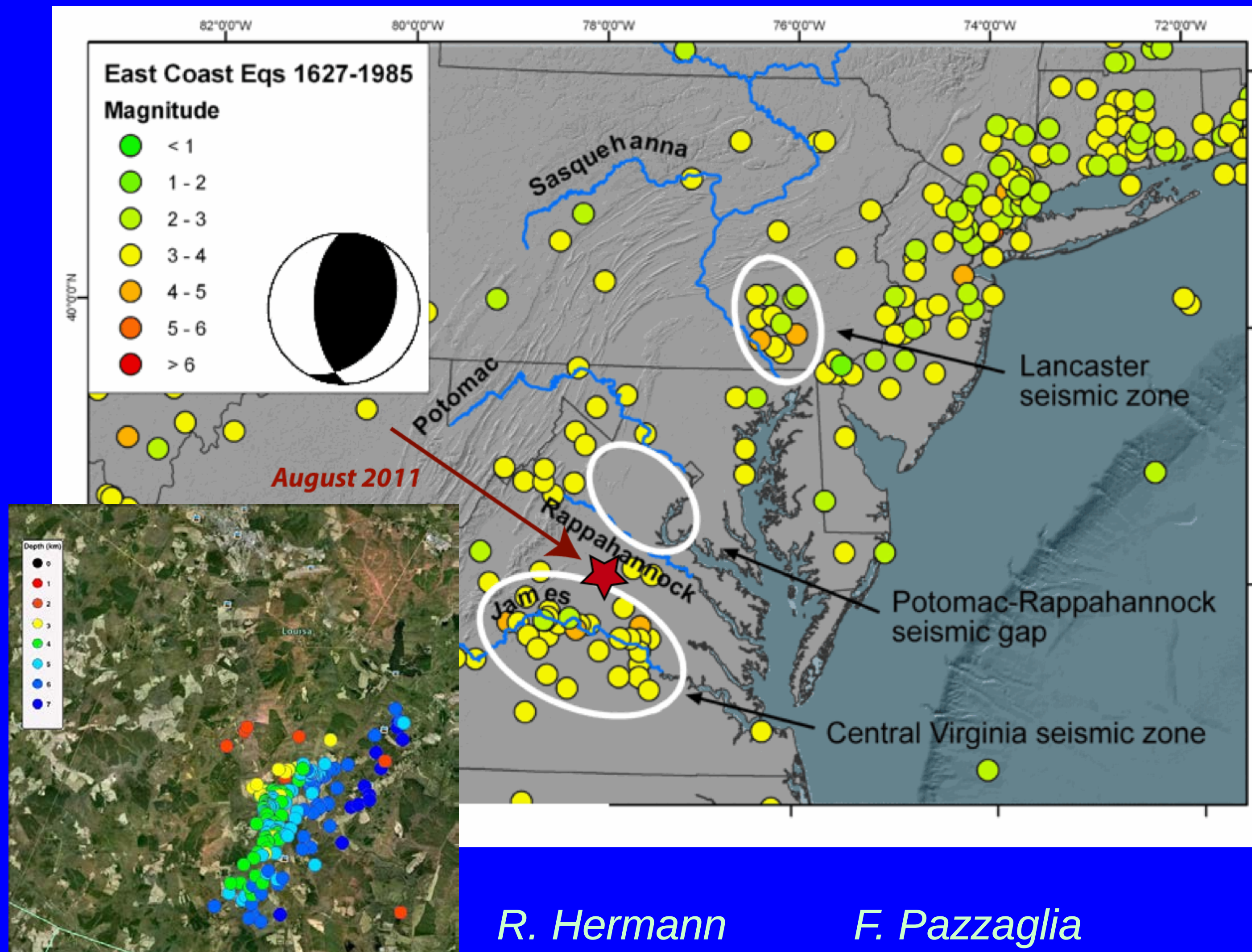
Hough et al, 2000

QuickTime™ and a
decompressor
are needed to see this picture.

GSC

Virginia 8/323/11: Reverse faulting on margin-parallel NE-SW striking, SE dipping fault

North edge of Central Virginia seismic zone, whose trend normal to the fault plane, margin, Appalachian Mountains & associated structures, has no clear geologic expression.



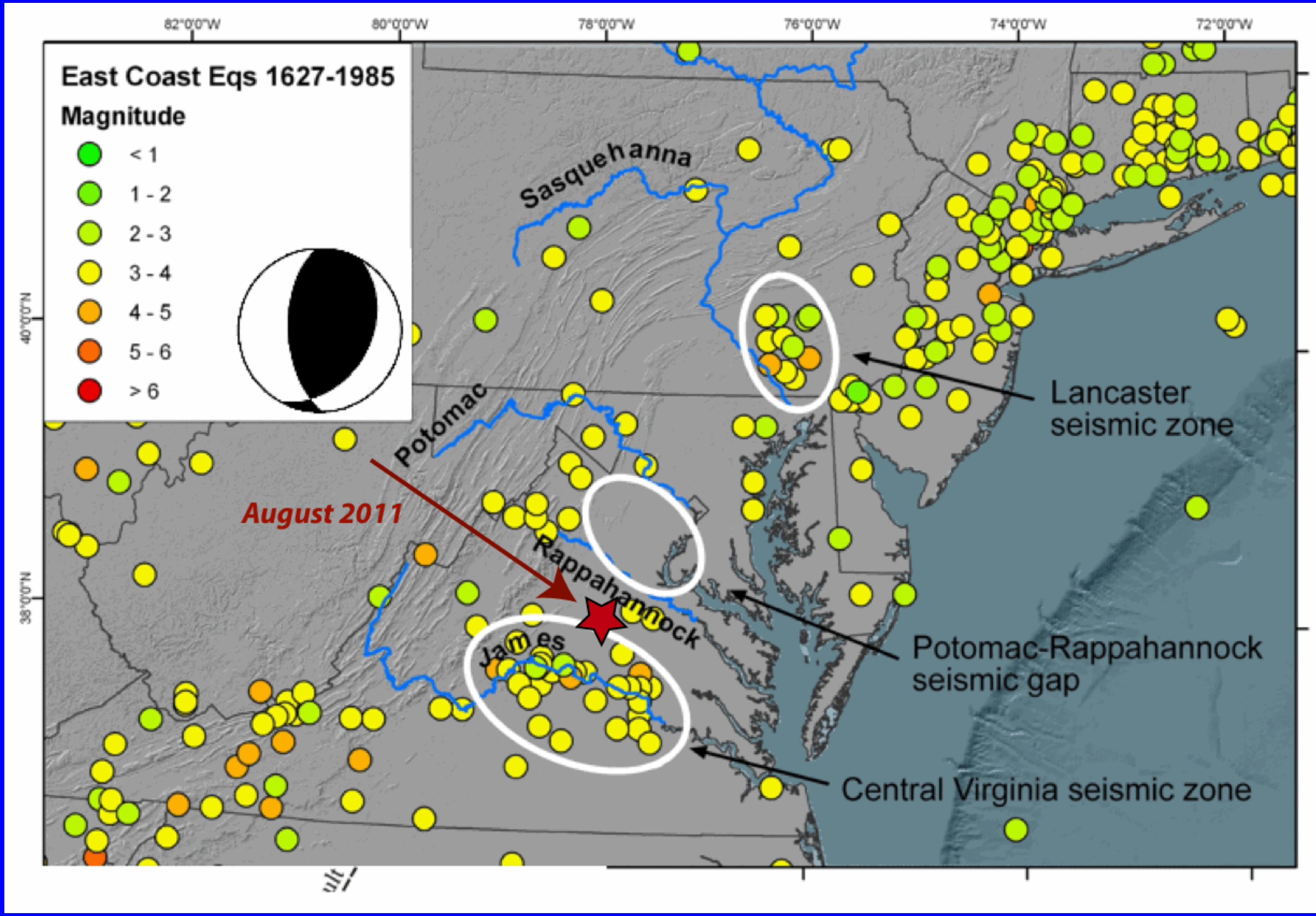
R. Hermann *F. Pazzaglia*

Unclear why this and similar seismic zones have the geometry they do

Unclear whether zones are more active over time, or present loci of activity that migrates.

Could some reflect aftershocks of large prehistoric earthquakes?

Are they related to regional uplift?

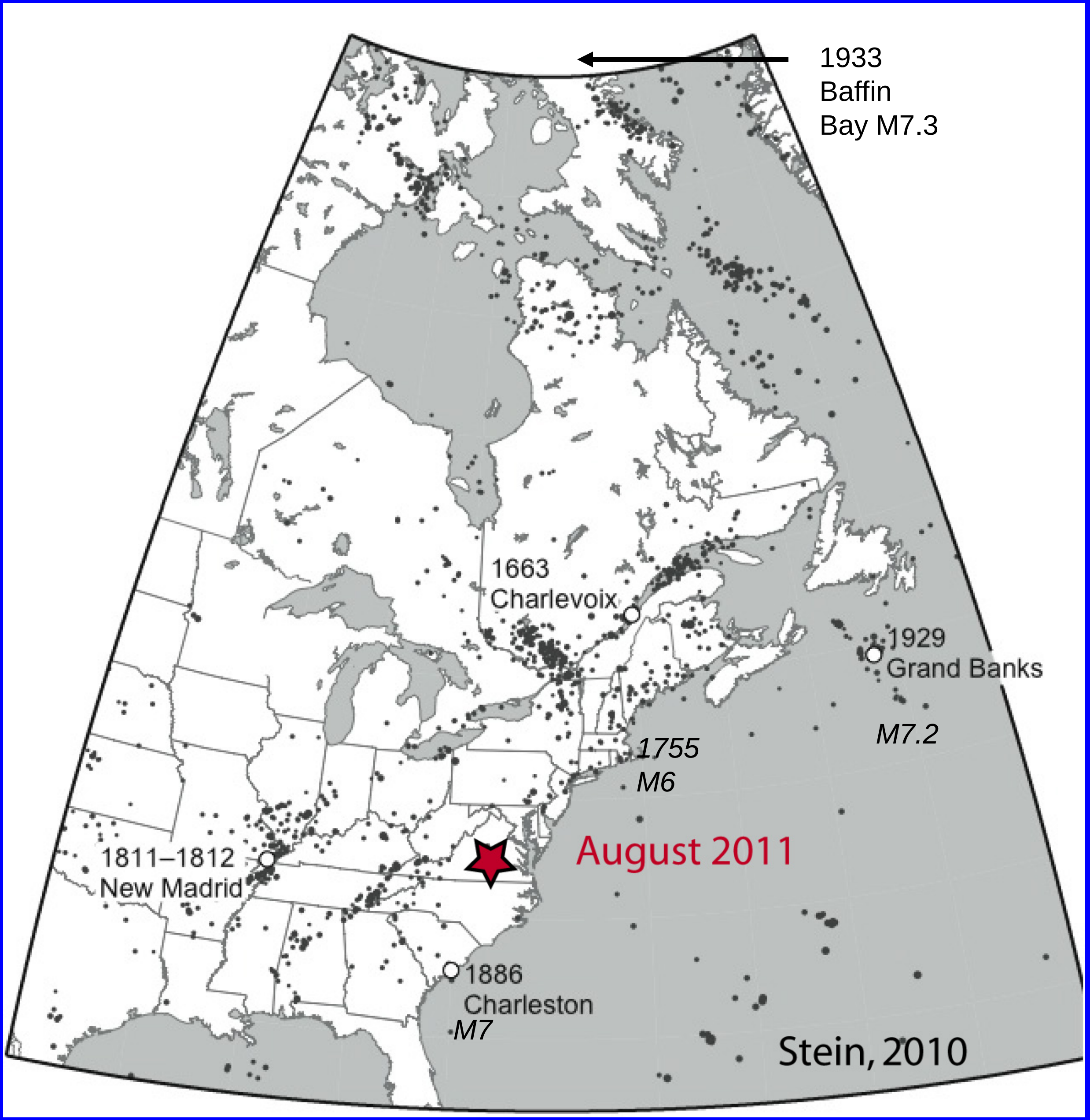


F. Pazzaglia

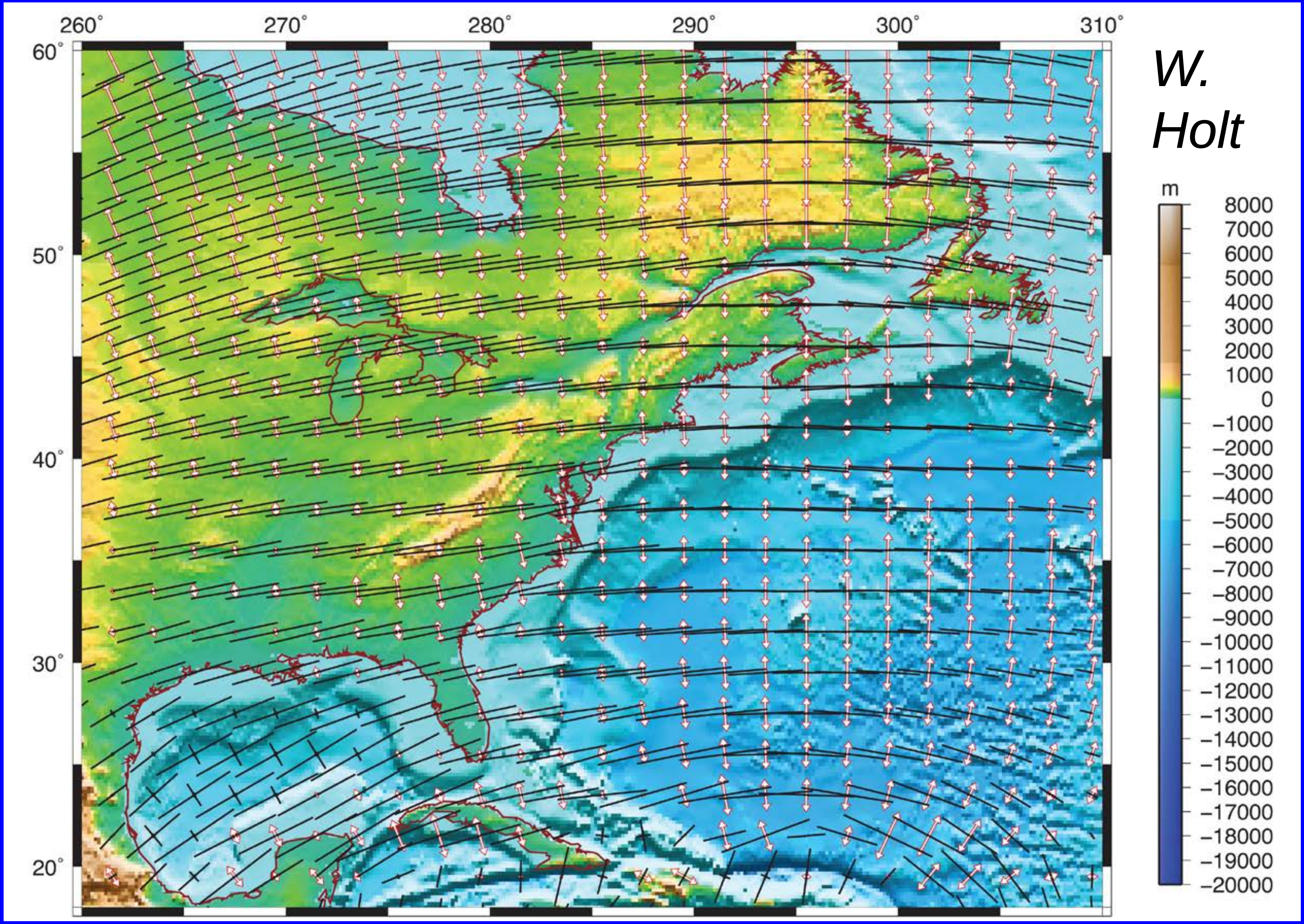
CAUSES?

Continental margin & plate interior contain many fossil faults developed at different times with different orientations but only a few appear active today

Platewide tectonic stresses, which change slowly in space and over millions of years, can't account for variability

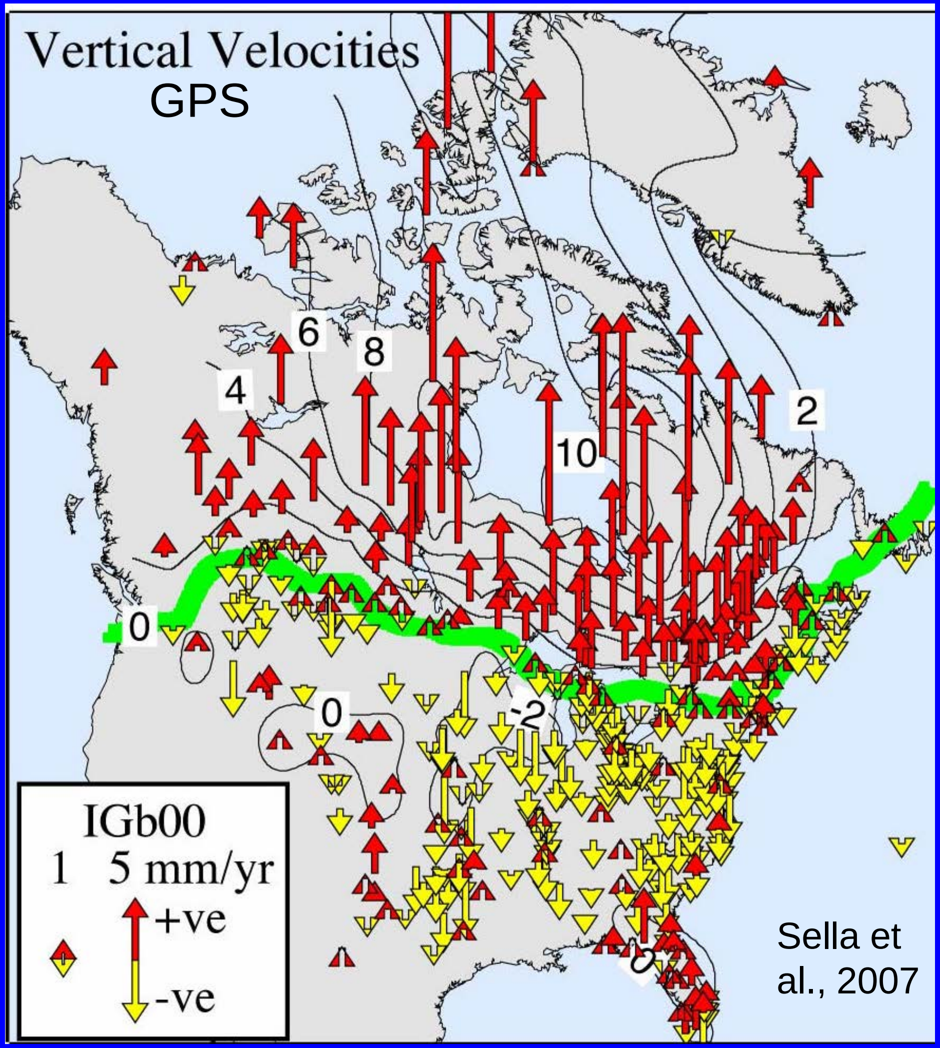


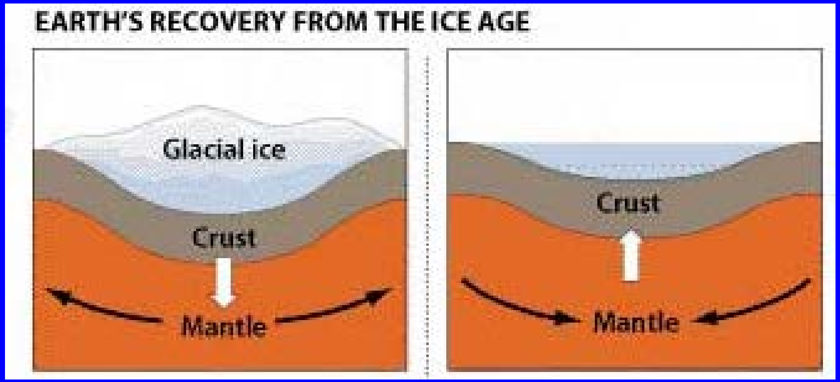
Compression predicted across margin



Includes lithospheric structure, topography & mantle flow

Additional possible stress source :
GIA - Glacial Isostatic Adjustment

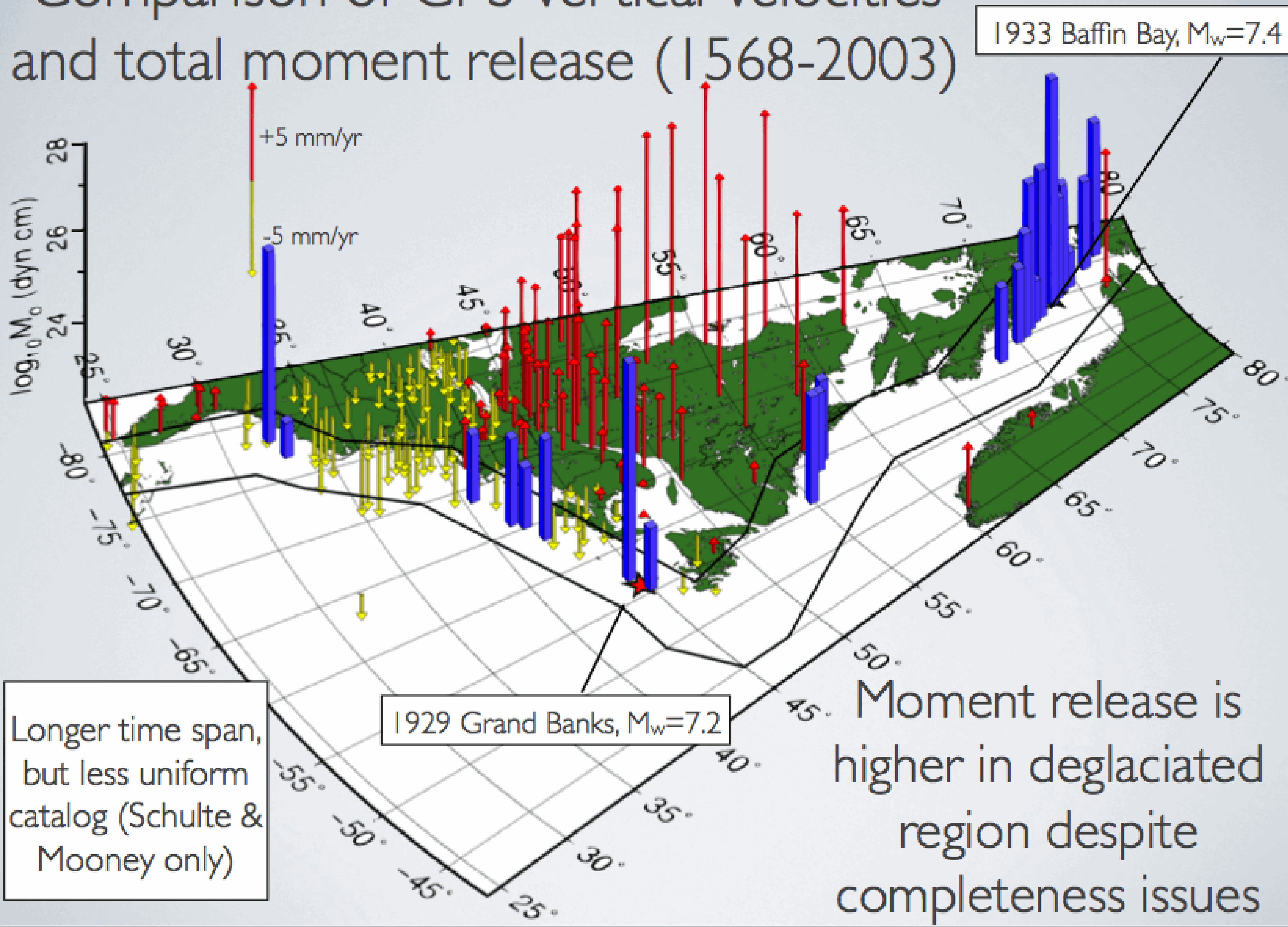




May explain seismicity along old ice sheet margin in Eastern Canada & elsewhere (Stein et al., 1979; 1989)

Effect should be less to south

Comparison of GPS vertical velocities and total moment release (1568-2003)



Longer time span, but less uniform catalog (Schulte & Mooney only)

Moment release is higher in deglaciated region despite completeness issues

Wolin & Stein, 2010

Extensions of Fracture Zones hypothesis (Sykes, 1978)

QuickTime™ and a
decompressor
are needed to see this picture.

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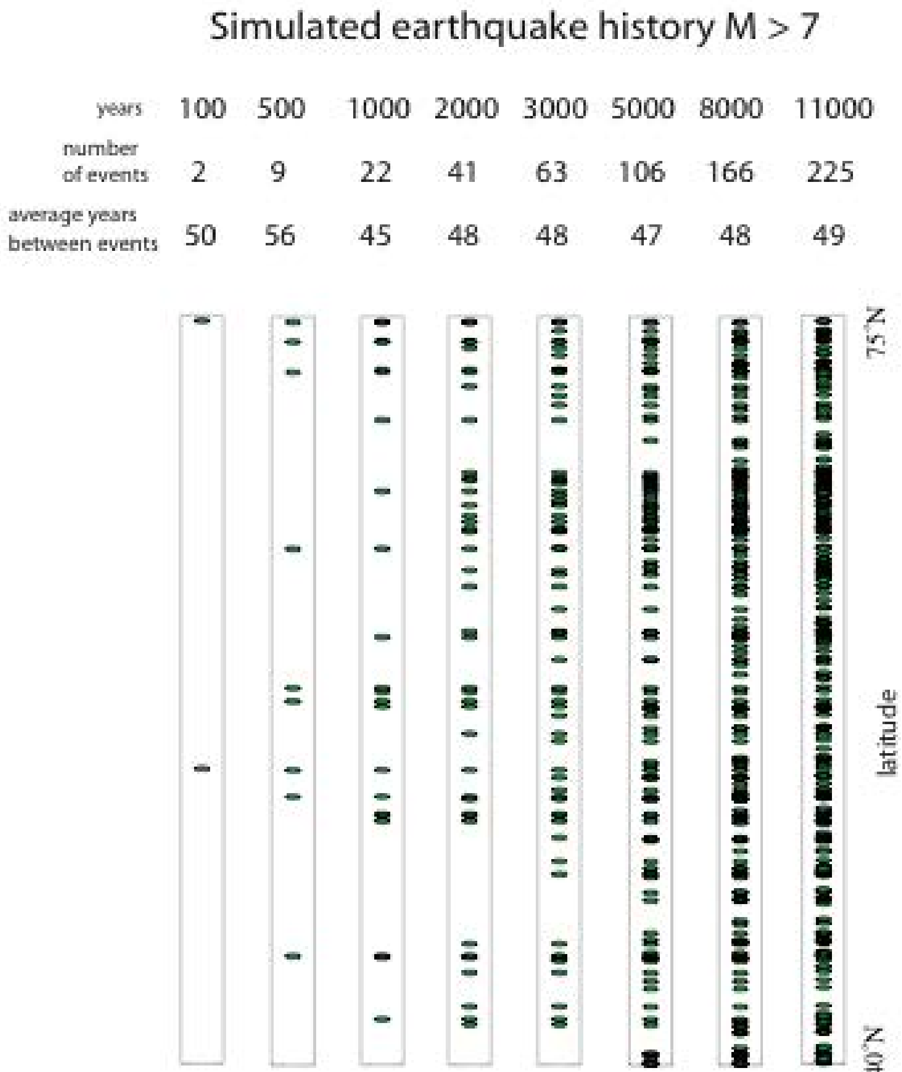
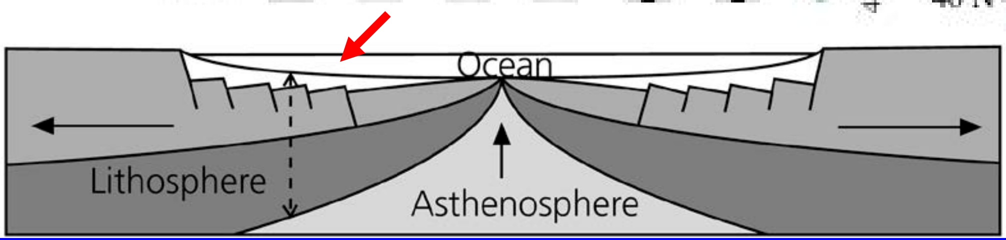
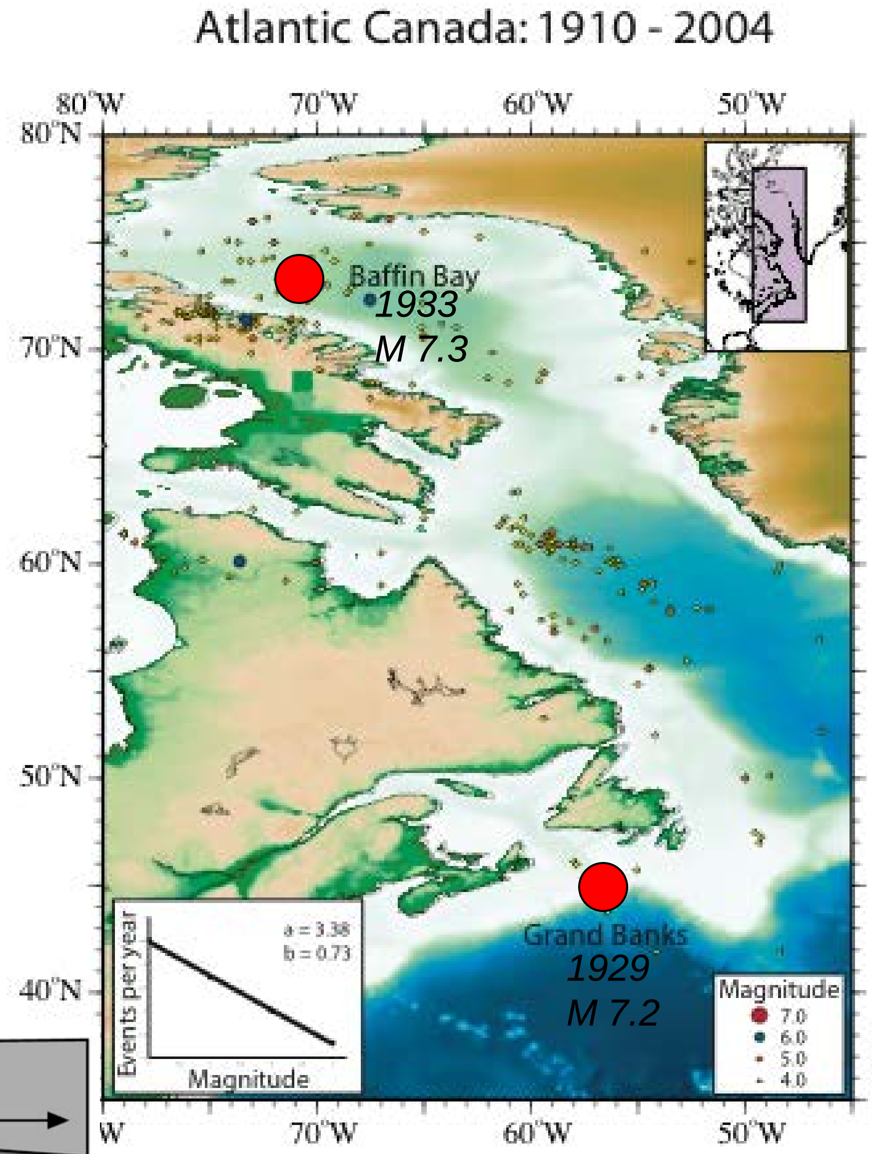
Inadequately describes locations

Long record needed to see real hazard





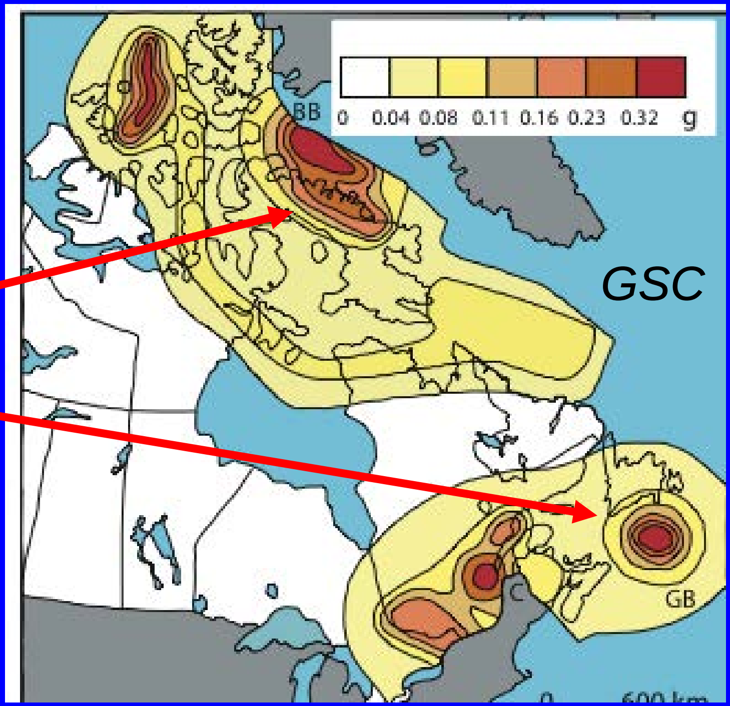


Swafford & Stein, 2007

Map depends greatly on assumptions & thus has large uncertainty

"Our glacial loading model suggests that earthquakes may occur anywhere along the rifted margin which has been glaciated."

Stein et al., 1979

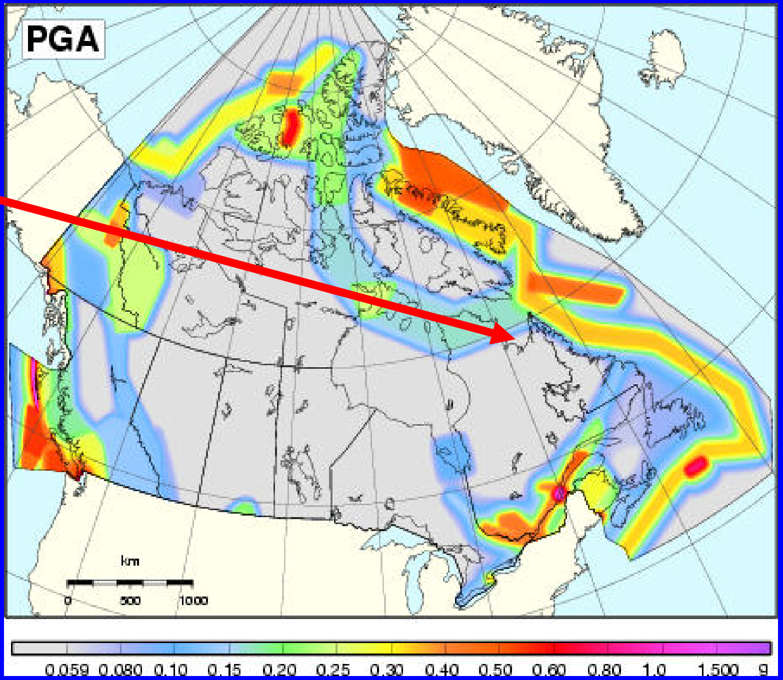


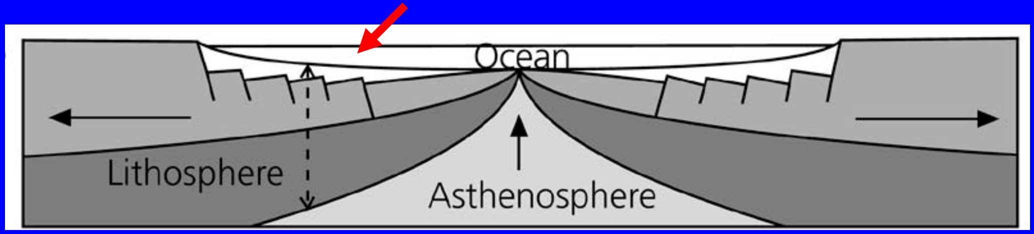
1985

Concentrated hazard bull's-eyes at historic earthquake sites

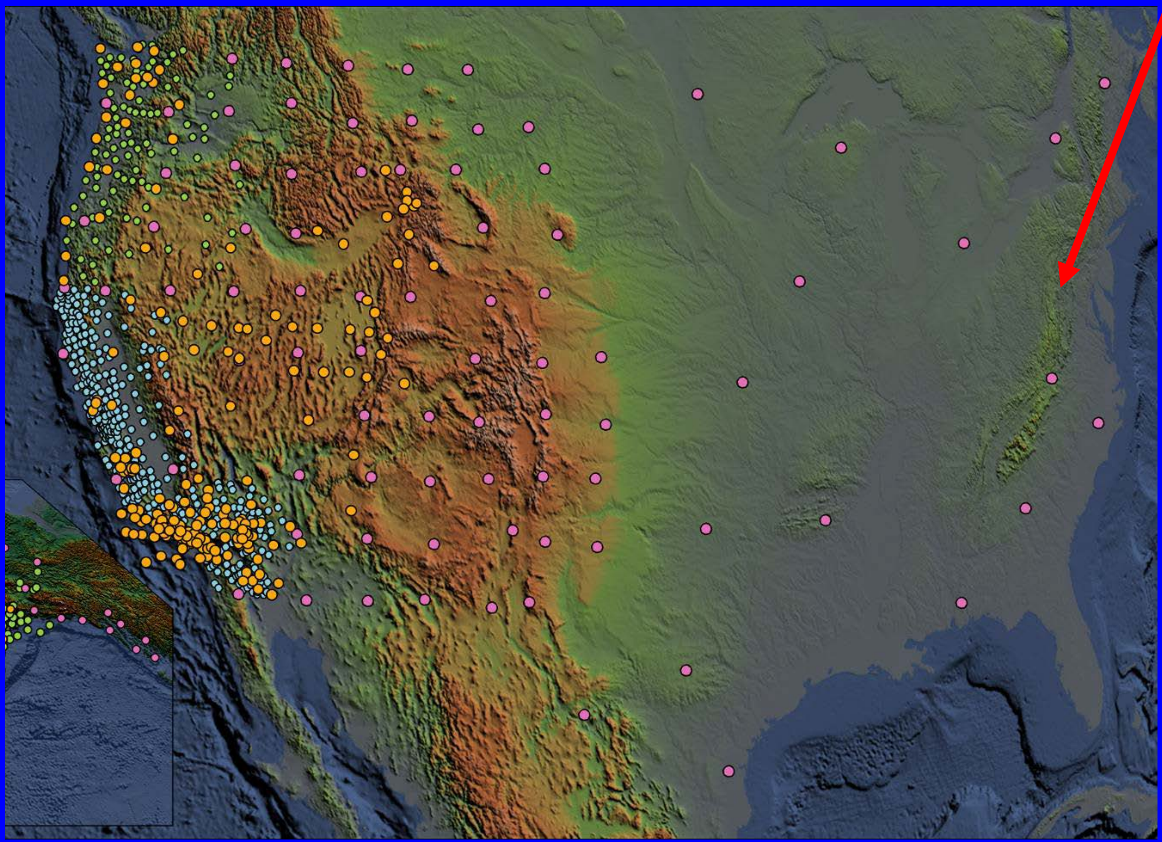
2005

Diffuse hazard along margin





Exciting Challenge: Find deformation and understand its causes & hazard



Present Plate Boundary Observatory

GPS, InSAR (Plate Interior Observatory)

Seismology, structural geology (map active & potentially seismogeneic structures)

Geomorphology (long term deformation)

Paleoseismology (look for past earthquakes)

Modeling (explain complexities)