Understanding midcontinent earthquakes: some challenges

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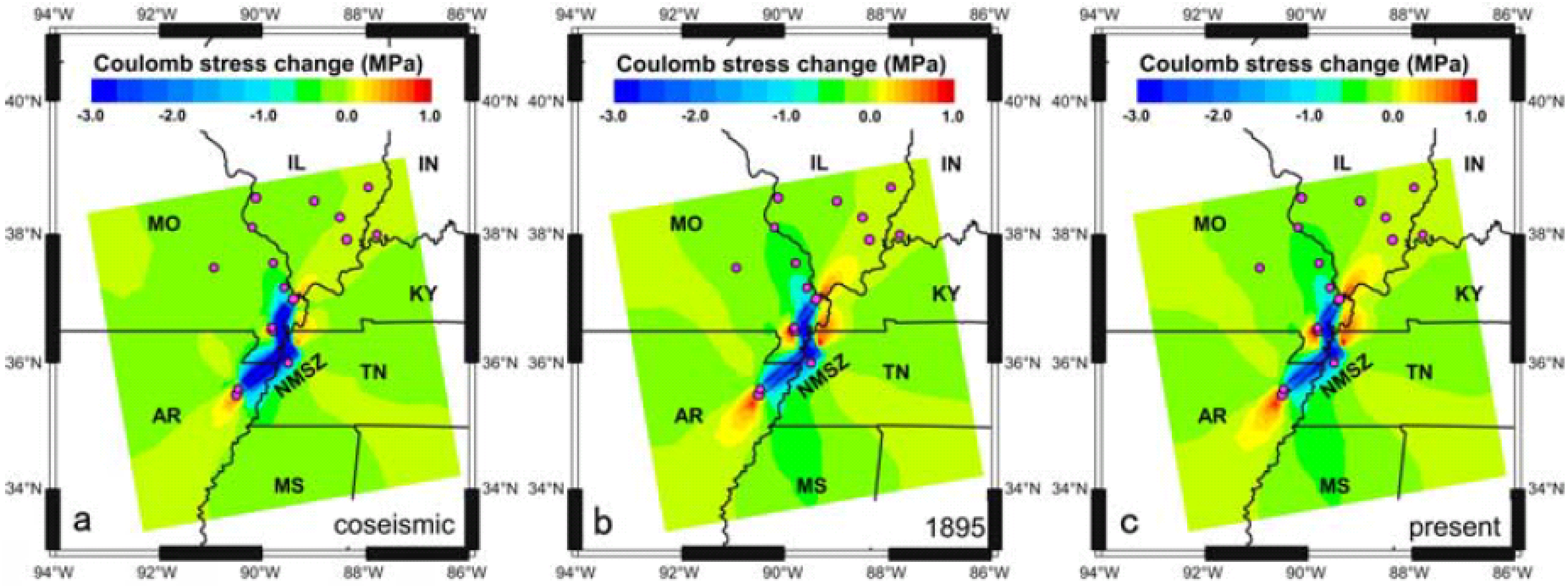
Some of the challenges:

- **Stress evolution following large earthquakes in mid-continents**: slow restoration – then what cause clustered eqs? How long can they continue?
- **Long sequences of aftershocks**: do today's small earthquakes indicate where the big ones will occur?
- **Timescale-dependent spatial patterns**: Blind men and an elephant?
- **Migrating earthquakes in N. China**: a different way to look at midcontinent earthquakes?

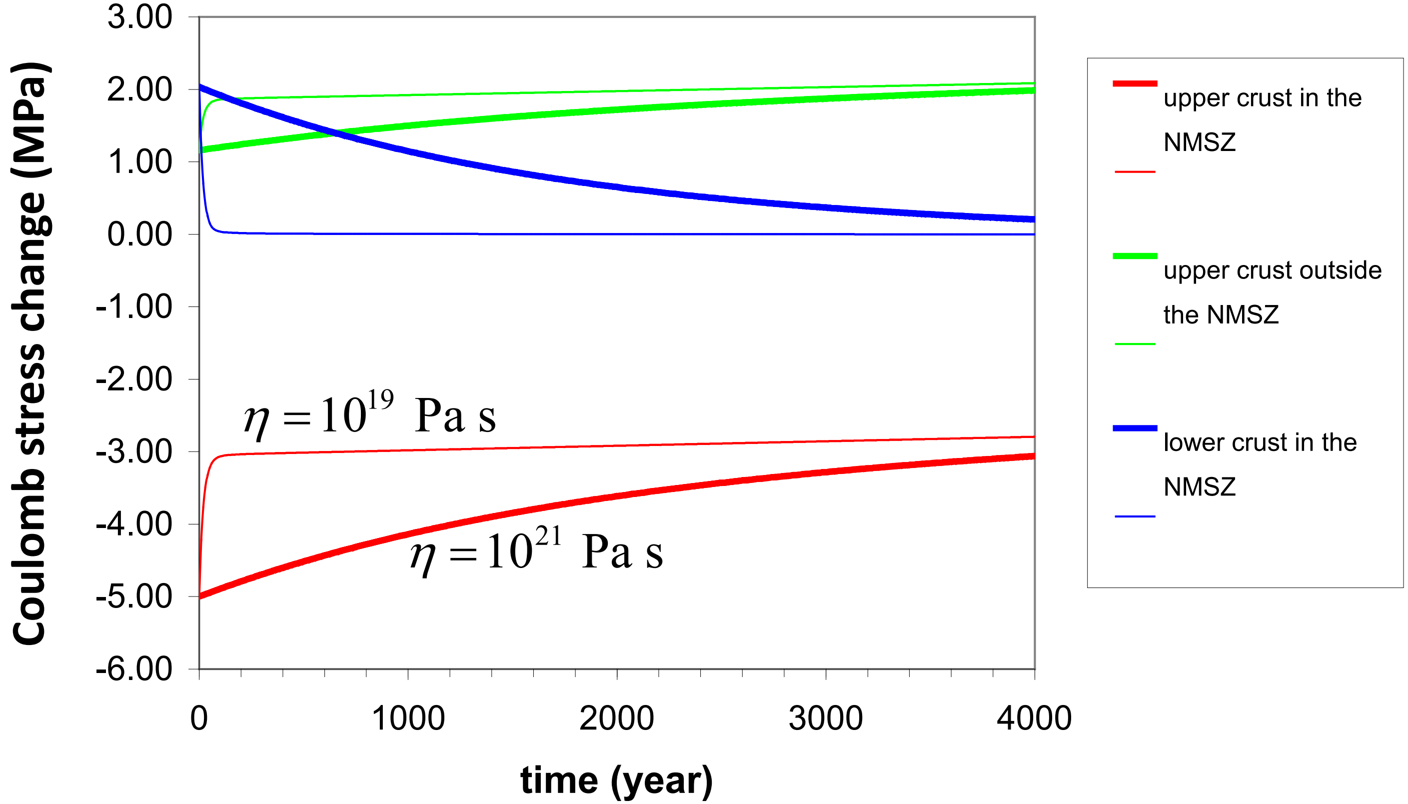
GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L11310, doi:10.1029/2004GL022133, 2005

Stress evolution following the 1811–1812 large earthquakes in the New Madrid Seismic Zone

Qingsong Li, Mian Liu, and Eric Sandvol



Predicted stress evolution following a large earthquake in NMSZ



With the typical tectonic loading rates in midcontinents, it takes thousands of years, or more, to recover stress in the fault zone after a large earthquake.

Fault weakening: one way to have clustered earthquakes

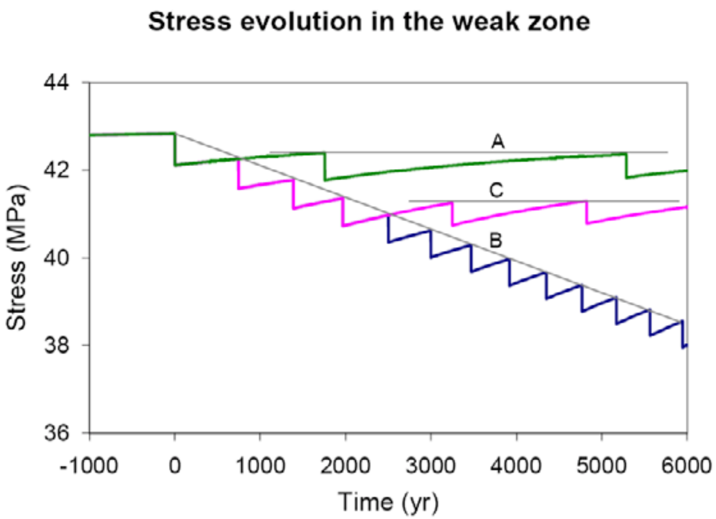
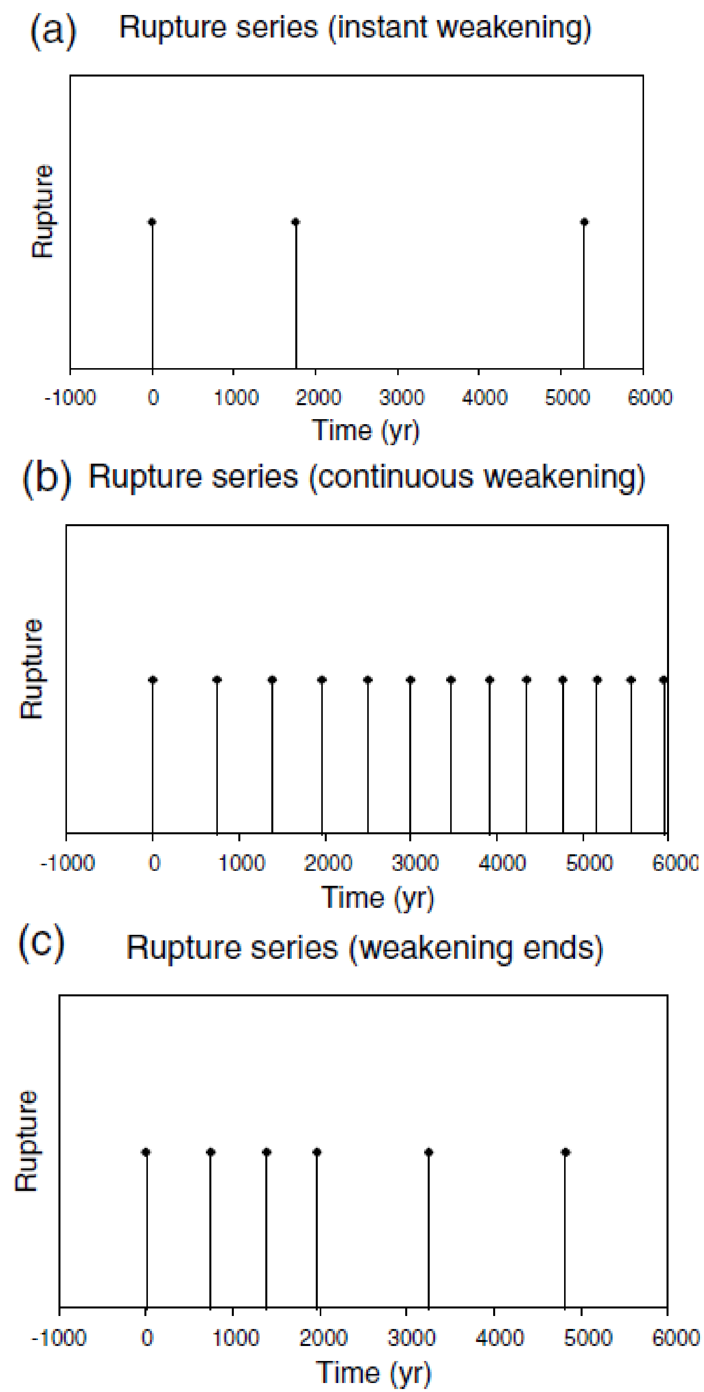


Figure 9 Stress evolution in the weak zone with different weakening scenarios: (a) instant weakening, (b) continuous weakening, and (c) continuous weakening that stops after 2000 yr. Gray lines indicate the yield strength in each weakening scenario.

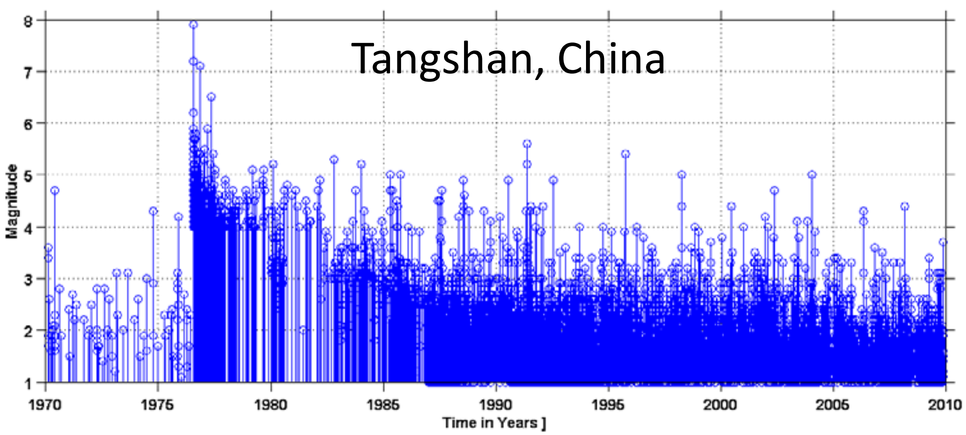


Vol 462|5 November 2009|doi:10.1038/nature08502

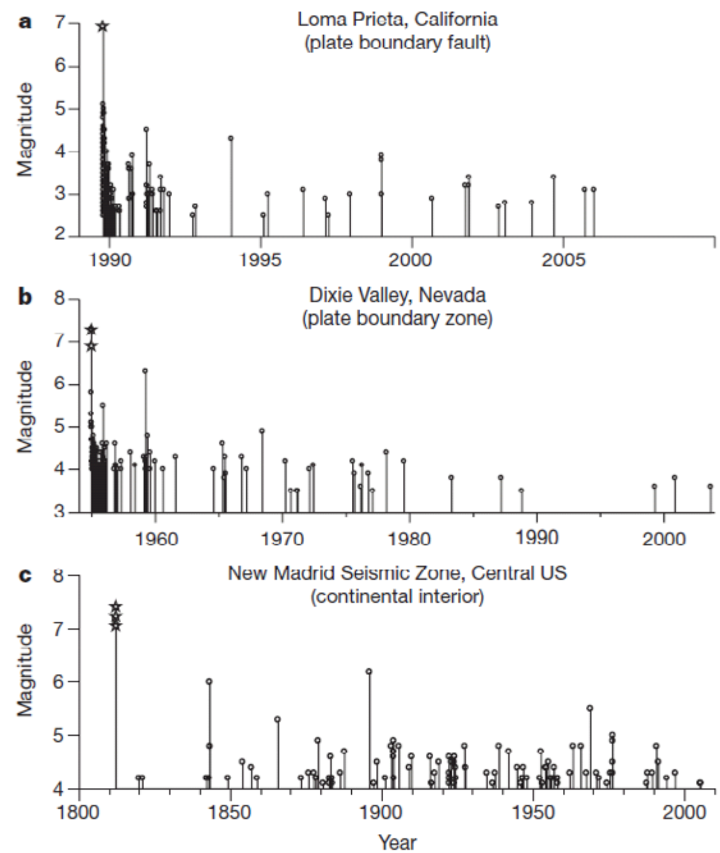
LETTERS

Long aftershock sequences within continents and implications for earthquake hazard assessment

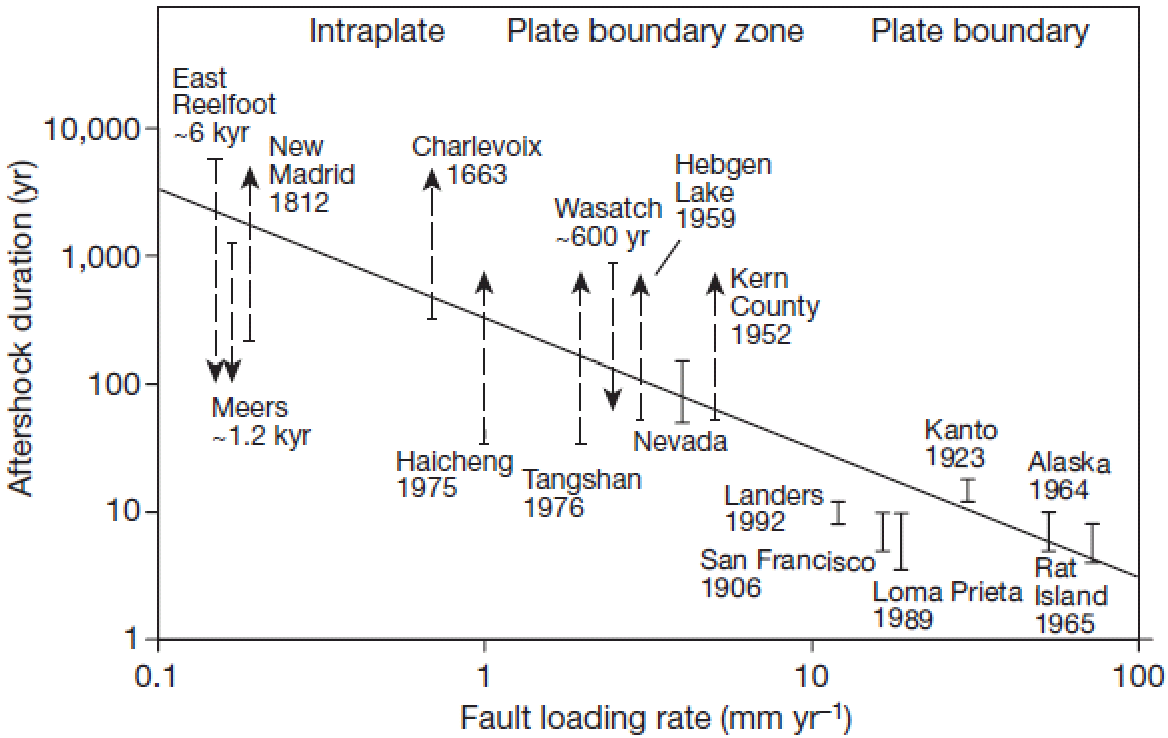
Seth Stein[1] & Mian Liu[2]



After 35 years, it's still going…



Long aftershock sequences in midcontinent

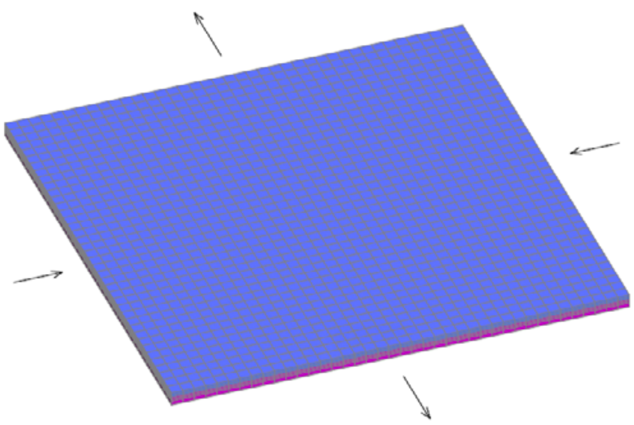


Long aftershock sequences in midcontinent are predicted from the rate- and state-dependent frictional law (Dieterich, 1994) or viscous relaxation, for the low stressing rates or high viscosity in midcontinent.

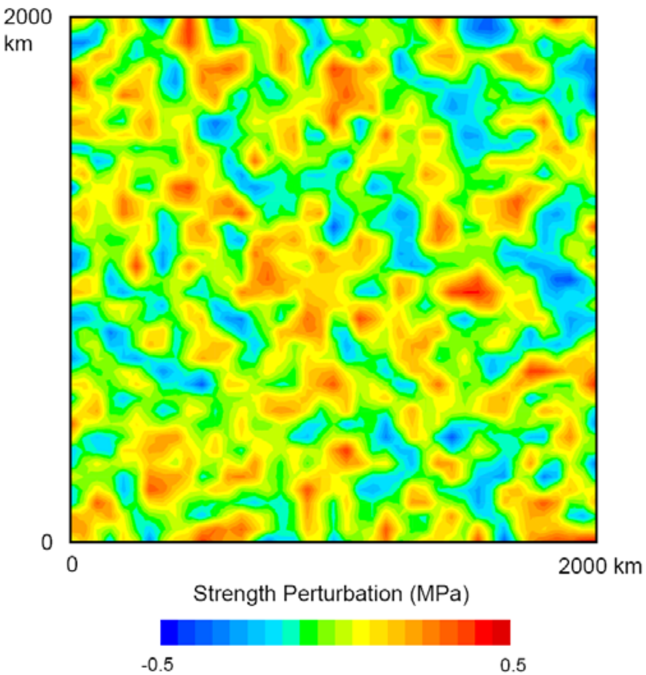
Bulletin of the Seismological Society of America, Vol. 99, No. 1, pp. 52–60, February 2009, doi: 10.1785/0120080005

Spatiotemporal Complexity of Continental Intraplate Seismicity: Insights from Geodynamic Modeling and Implications for Seismic Hazard Estimation

by Qingsong Li, Mian Liu, and Seth Stein

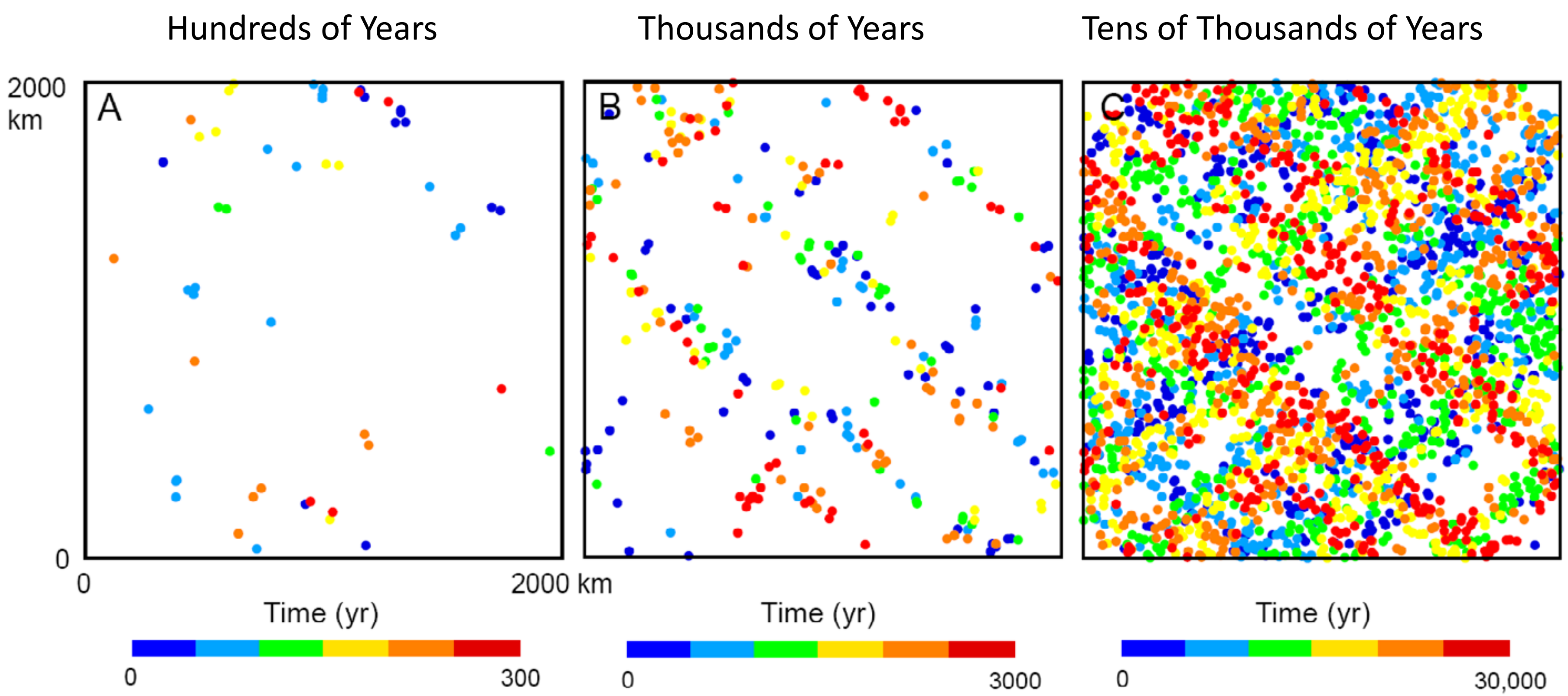


A simple viscoelastic FE model



Initial random stress perturbation

Predicted seismicity on different time scales



Over 100s of years, predicted seismicity shows both spatial clustering (in narrow belts) and scattering (across large regions).

Over a longer period (1000s of years), predicted seismicity forms networked belts, apparently aligned with the regional orientations of maximum shear stress.

Over an even longer period (10,000s of years), the predicted seismicity appears to be randomly scattered everywhere.

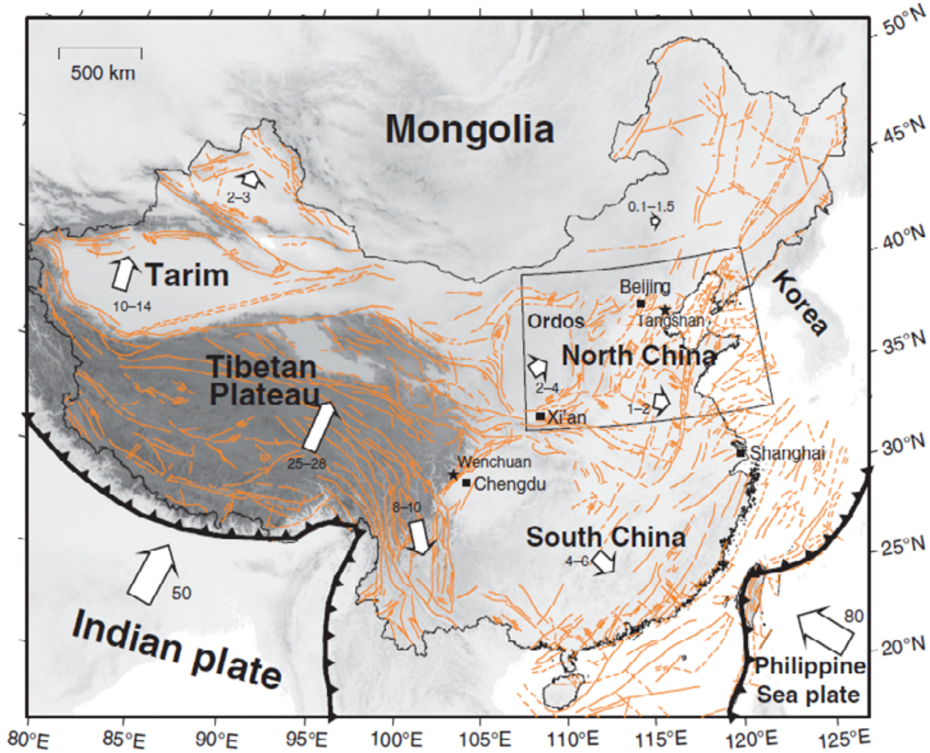
Do we see the whole elephant?

LITHOSPHERE Data Repository item 2011080. doi: 10.1130/L129.1

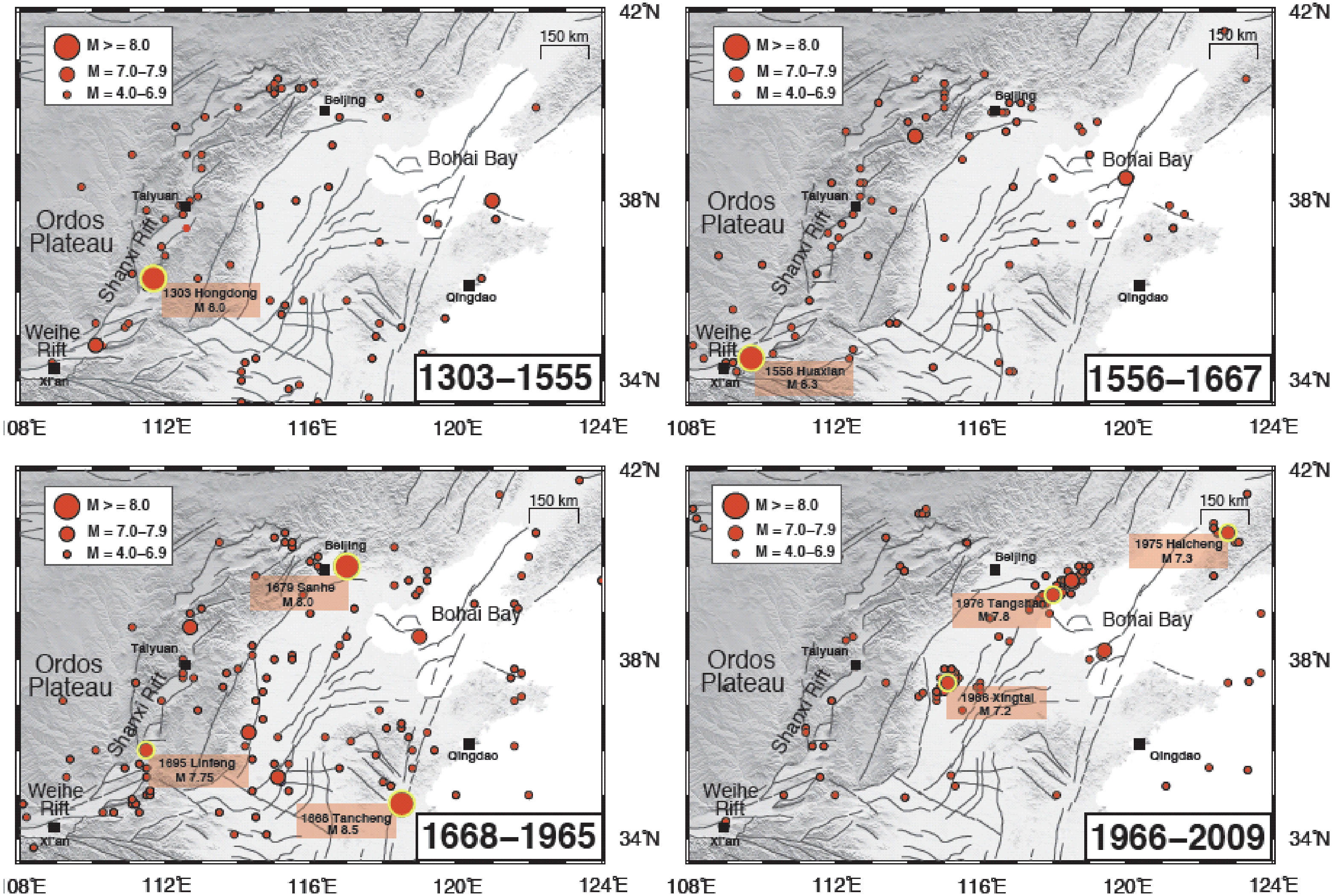
SHORT RESEARCH

2000 years of migrating earthquakes in North China: How earthquakes in midcontinents differ from those at plate boundaries

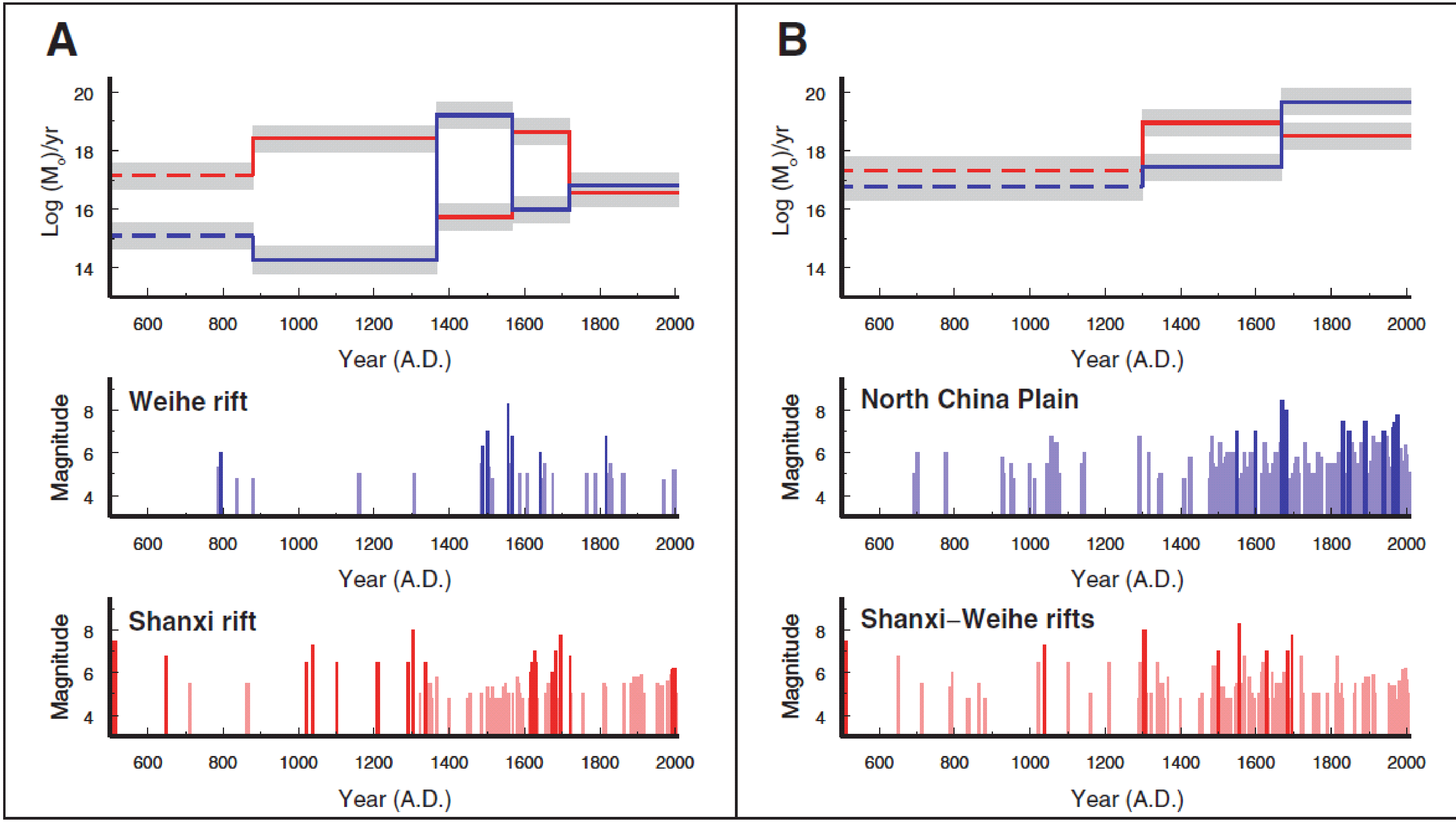
Mian Liu[1,*], Seth Stein[2], and Hui Wang[3]



Migrating Large Earthquakes In North China



No large ruptures have repeated on the same fault segment in the past 2000 years!



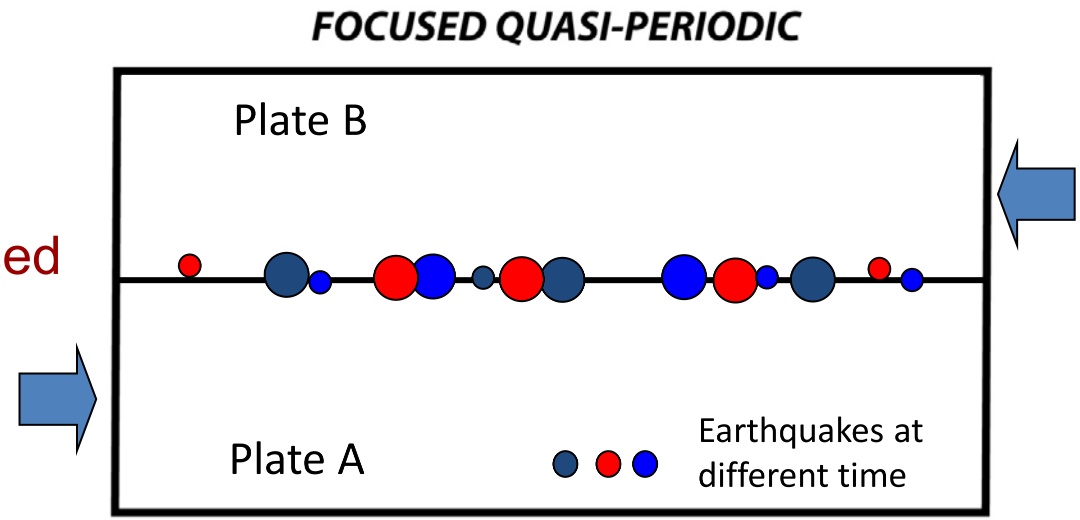
Complementary moment release between major fault systems indicates mechanical coupling between these faults

At a plate boundary:

•Plate boundary fault is loaded rapidly at constant rate

•Earthquakes are spatially focused & temporally quasi-periodic

Past is good predictor



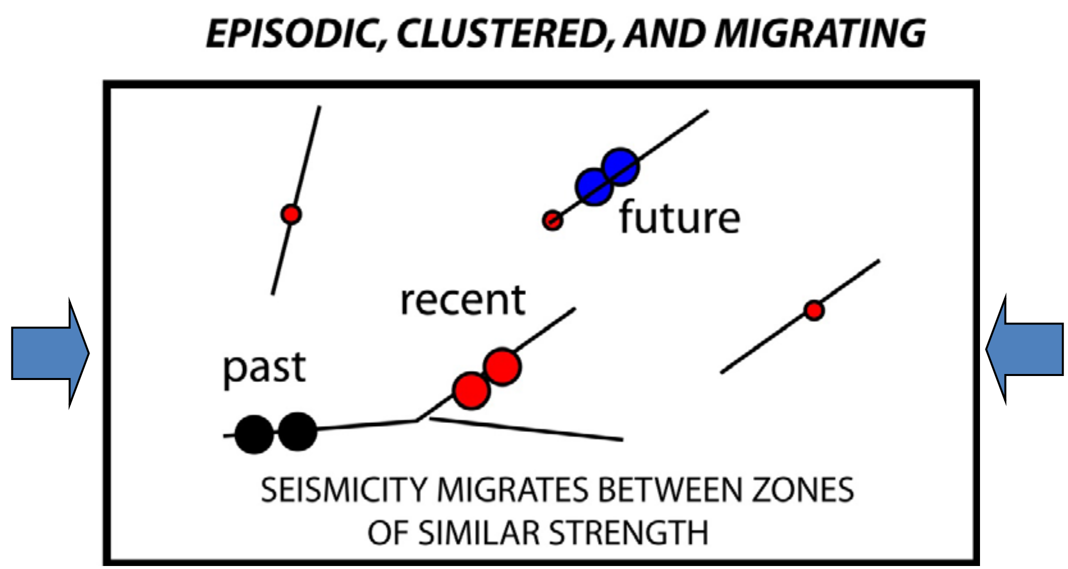
In Midcontinent:

•Tectonic loading collectively accommodated by a complex system of interacting faults

•Loading rate on a given fault is slow & may not be constant

•Earthquakes can cluster on a fault for a while then shift

Past can be poor predictor



Liu, Stein and Wang, 2011

Thank you!

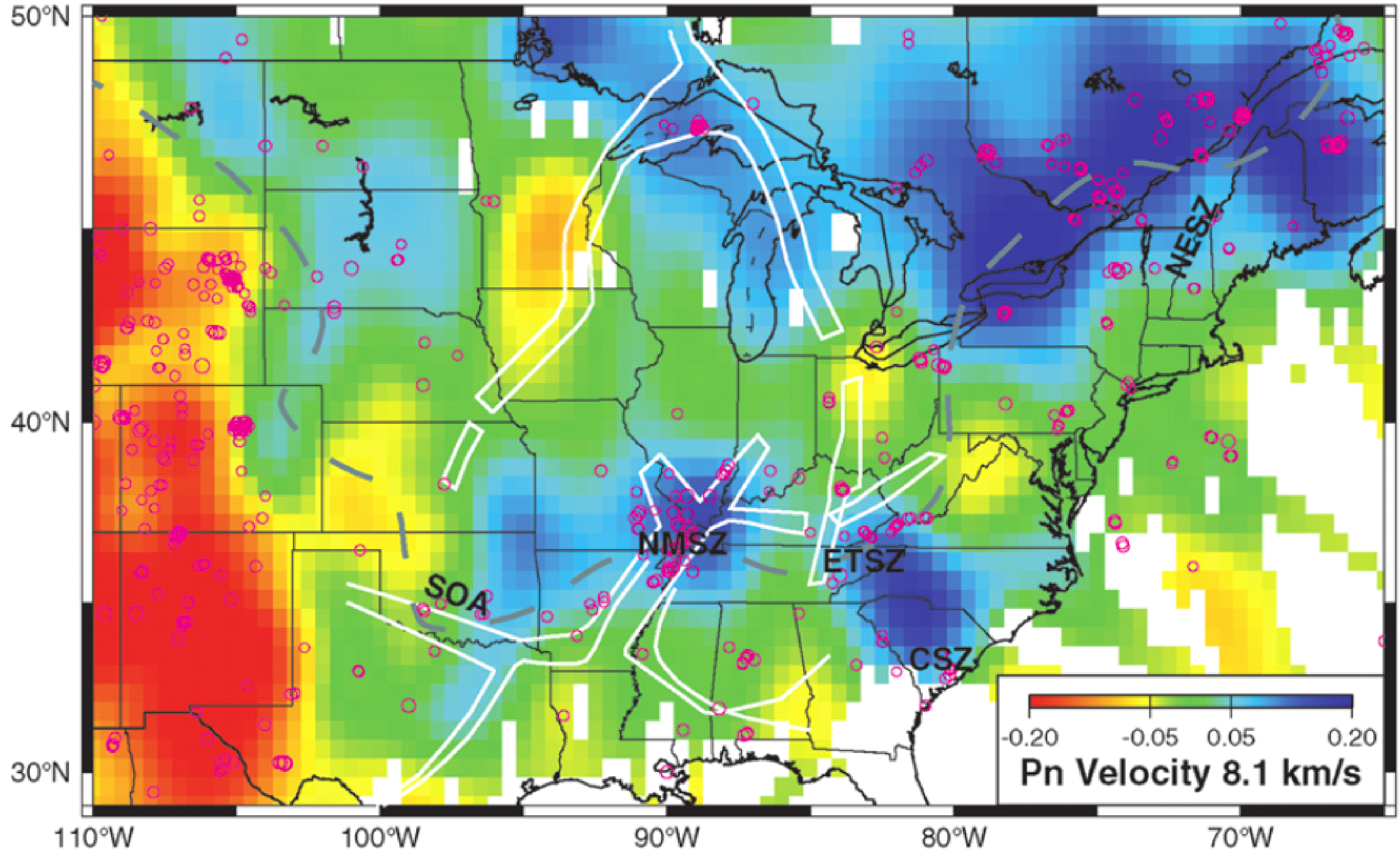
Bulletin of the Seismological Society of America, Vol. 99, No. 1, pp. 422–427, February 2009, doi: 10.1785/0120080246

Short Note

Tomographic *Pn* Velocity and Anisotropy Structure in the Central and Eastern United States

by Qie Zhang, Eric Sandvol, and Mian Liu

(a)



GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L11305, doi:10.1029/2009GL037687, 2009

Lithospheric velocity structure of the New Madrid Seismic Zone: A joint teleseismic and local P tomographic study

Qie Zhang,[1] Eric Sandvol,[1] and Mian Liu[1]