Understanding midcontinent earthquakes: some challenges

Mian Liu
Dept. of Geological Sciences
University of Missouri
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?
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.

\[ \eta = 10^{19} \text{ Pa s} \]

\[ \eta = 10^{21} \text{ Pa s} \]
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.
Long aftershock sequences within continents and implications for earthquake hazard assessment

Seth Stein¹ & Mian Liu²

Tangshan, China

After 35 years, it’s still going...
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.
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
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?
2000 years of migrating earthquakes in North China: How earthquakes in midcontinents differ from those at plate boundaries

Mian Liu¹, Seth Stein², and Hui Wang³
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
Thank you!
Short Note

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

by Qie Zhang, Eric Sandvol, and Mian Liu
Lithospheric velocity structure of the New Madrid Seismic Zone: A joint teleseismic and local P tomographic study

Qie Zhang, Eric Sandvol, and Mian Liu