BRIEF OVERVIEW
OF
SEISMIC THREAT TO THE ST. LOUIS AREA POSED BY THE NEW MADRID SEISMIC ZONE

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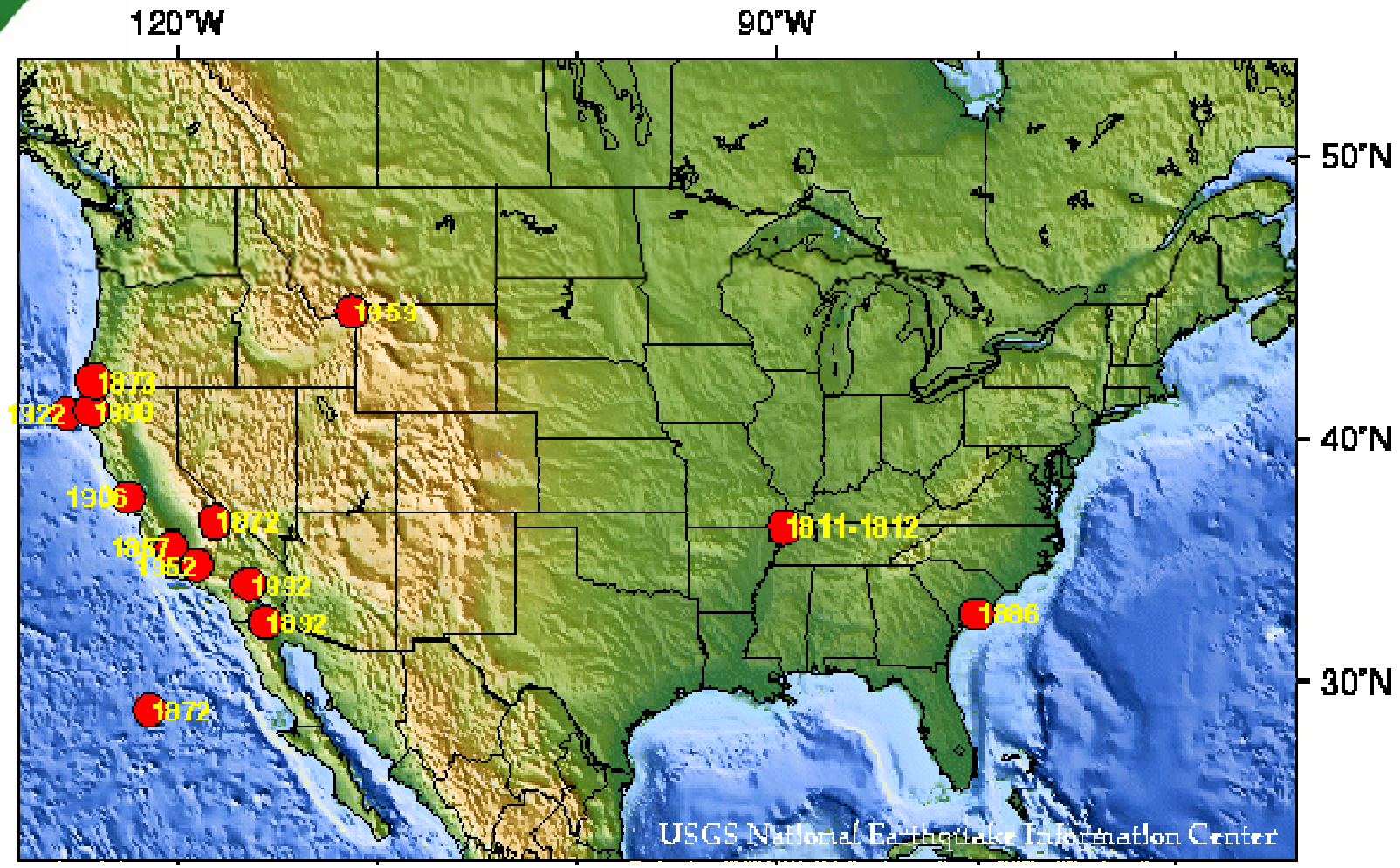

- **In 1663 the European settlers experienced their first earthquake in America. From 1975-1995 there were only four states that did not have any earthquakes: Florida, Iowa, North Dakota, and Wisconsin. The most damaging earthquakes have occurred in California, Nevada and Alaska. Should we be concerned in the Midwest?**

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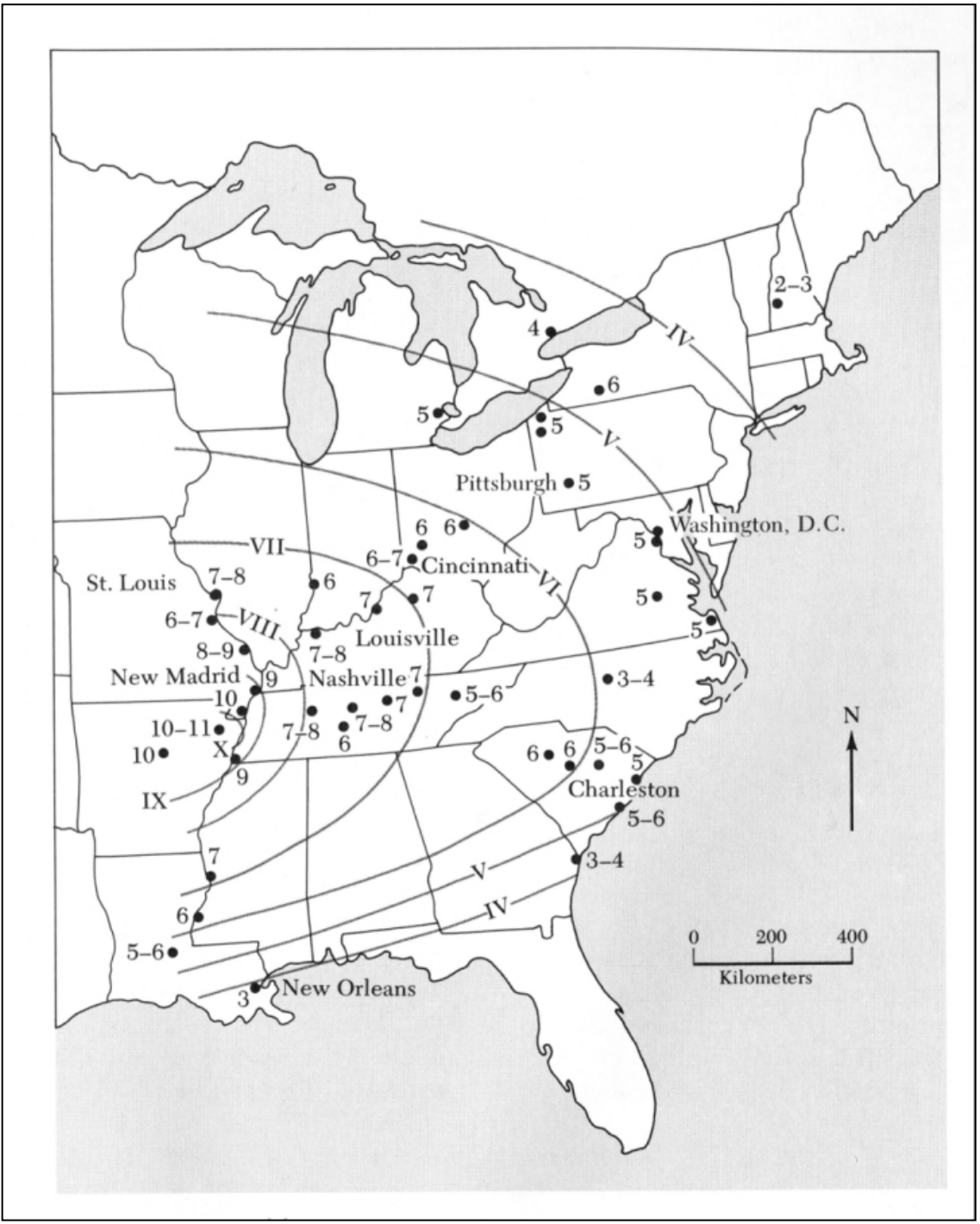
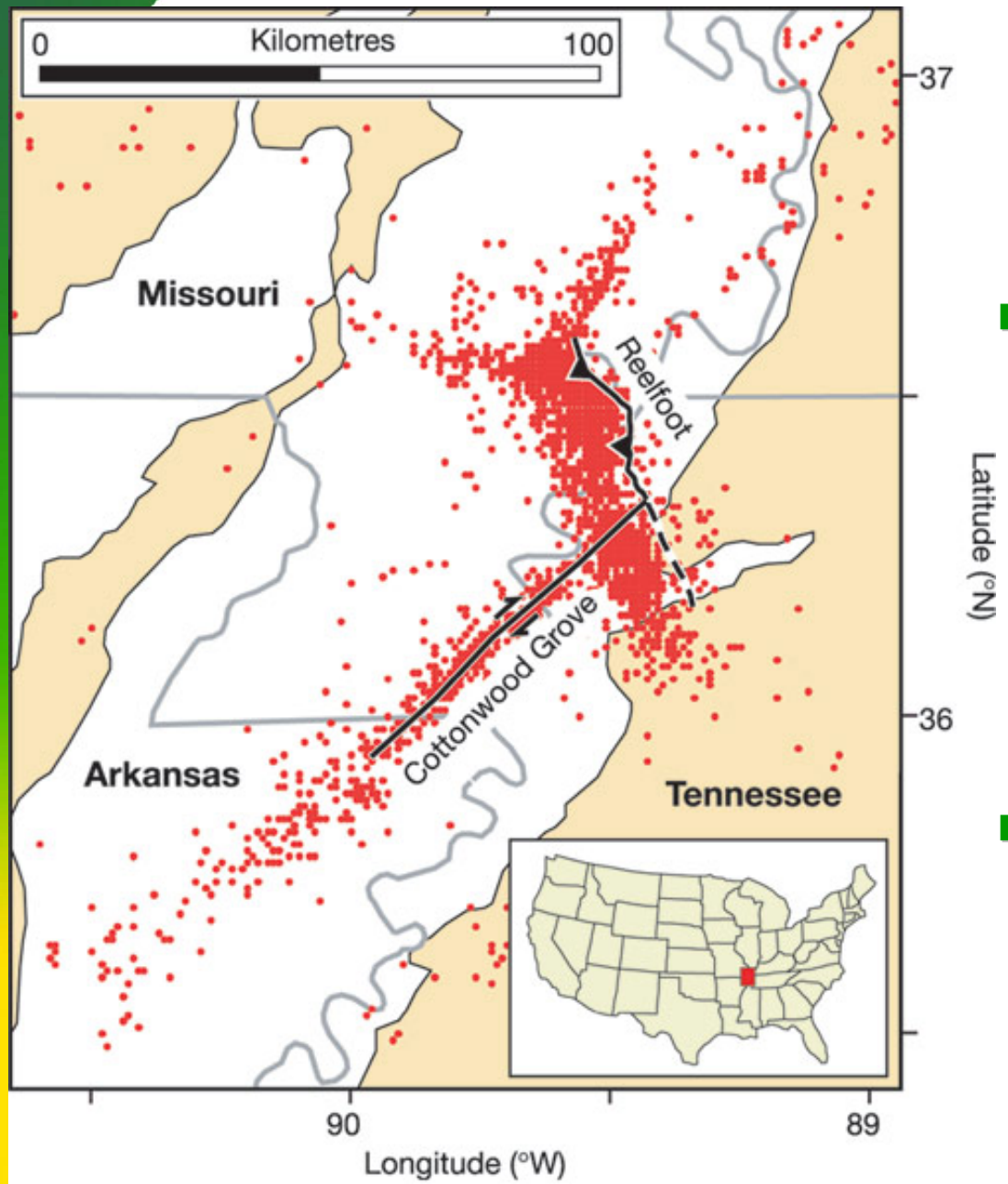


- Isoseismal lines for the December 16, 1811 M 7.7 New Madrid earthquake
- Felt over an area greater than 1 million square miles
- Extensive damage to masonry in Cincinnati
- Rang church bells in Boston
- Most people lived along rivers in Midwest and no inhabitants west of the Mississippi

NEW MADRID SEISMIC ZONE

- 2000 quakes in New Madrid Seismic Zone in 1811-12; four with M> 7.5
- Felt over 1 million square miles!
- Chimneys toppled in Cincinnati, Ohio, 350 miles away
- Raised and lowered vast tracts of land as much as 20 feet, temporarily reversing flow of Mississippi River
- Ground fissures and massive liquefaction over a zone measuring 10,000 square miles!

ACTIVE SEISMICITY



- Epicenters recorded between 1974-96 describe a seismically active zone of complex intraplate tectonics
- Right lateral strike slip and blind thrust faulting occur in the same region

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POST 1812 SEISMICITY in NEW MADRID SEISMIC ZONE

- **M6.3 quake in Marked Tree, AR in 1843; did considerable damage to Memphis, 60-70 km east**
- **M6.6 quake in Charleston, MO in 1895; Felt in 23 states, 30 km of sand blows**
- **M5.4 in Wabash Valley (Dale, IL) in 1968; also felt in 23 states; light damage in St. Louis**
- **M5.0 in Wabash Valley west of Vincennes, IN (Olney, IL) in 1987**
- **M4.6 near Evansville, IN in 2002**

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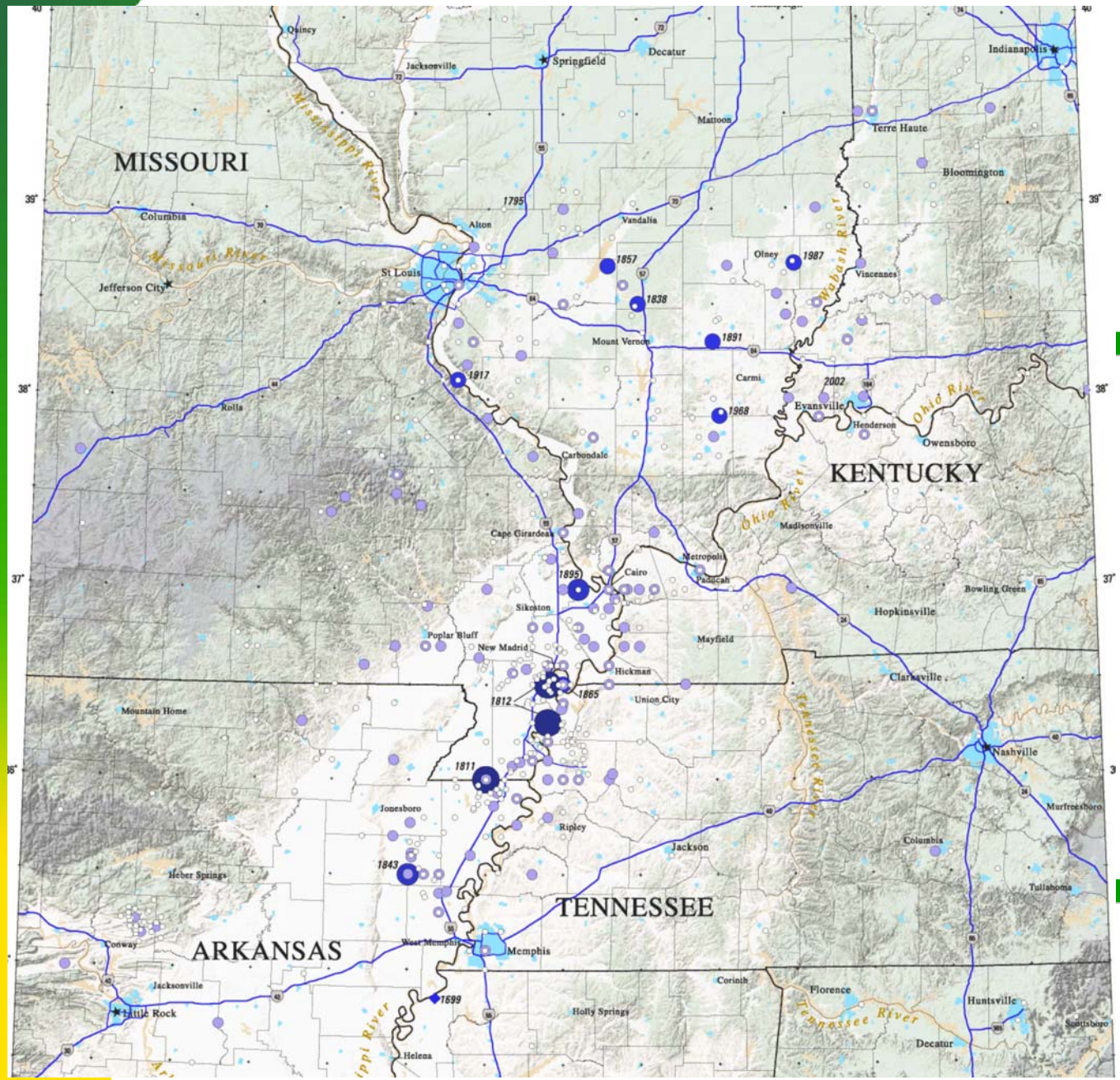

OTHER SEISMIC SOURCES

- Not all of the region's quakes emanate from the recognized New Madrid Zone
- Other sources likely

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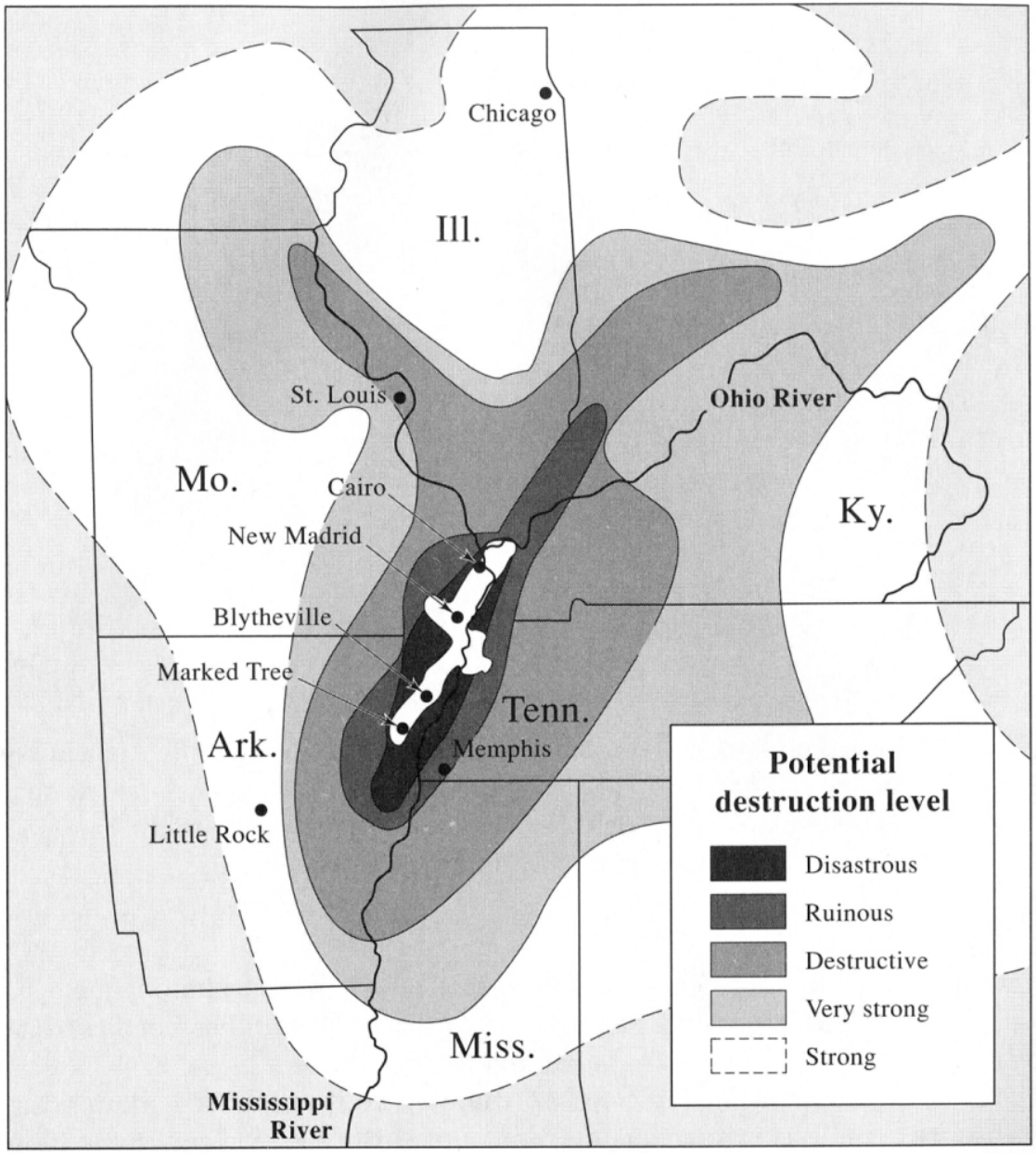
DAMAGE POTENTIAL



Published damage predictions for the New Madrid Seismic Zone have focused on the near field area, in the upper Mississippi Valley

These are based on synthetic motion time histories with assumed soil cover; not on site specific characteristics or dynamic properties of structures.

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LIQUEFACTION

Liquefaction is a failure mechanism by which cohesionless materials lose shear strength when the pore pressure is excited to a level equal to the effective confining stress. Usually limited to the upper 50 feet and typically occurs in silt, sand and fine gravel.

- **Recent sand blows dot the landscape surrounding New Madrid, MO, testifying to massive liquefaction**

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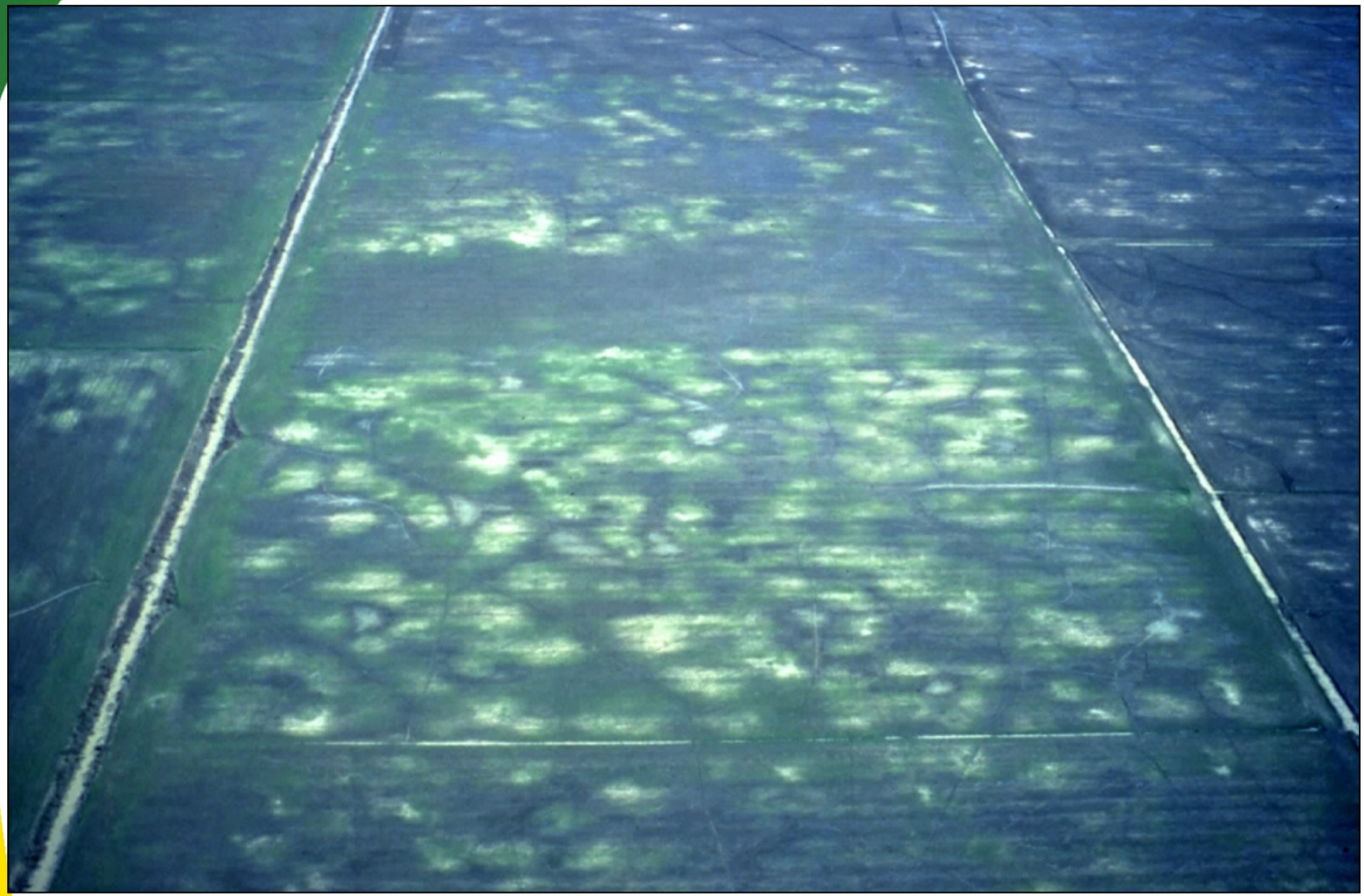

- **Enormous tracts of land exhibit evidence of paleoliquefaction – on a grandiose scale**

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- **Farm lands west of Big Lake, AR reveal a series of linear fissures which disgorged liquefied sand from beneath a silt cover.**

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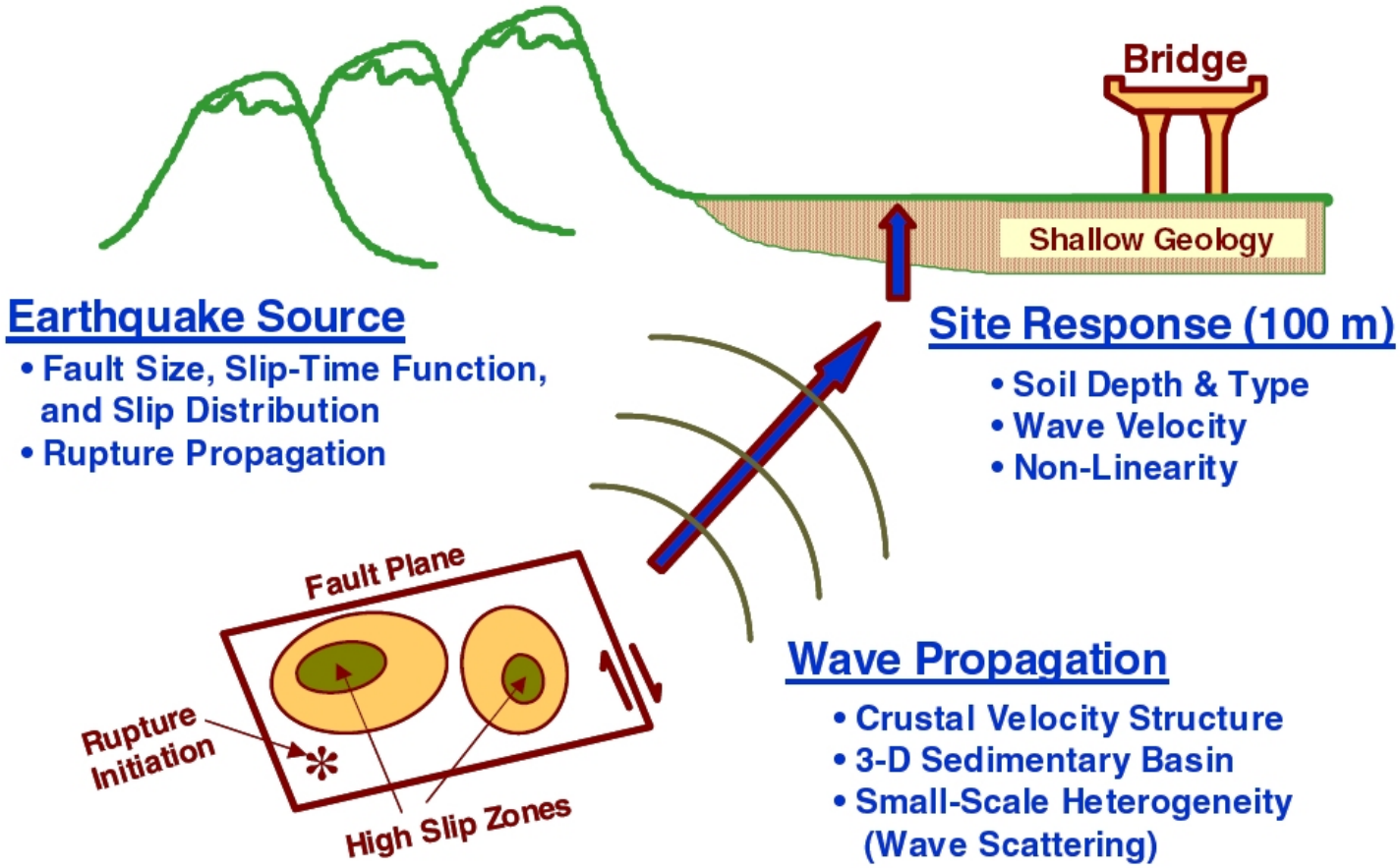

- **The type, depth and size of earthquake combine with geophysical properties of the underlying geology to affect seismic site response**

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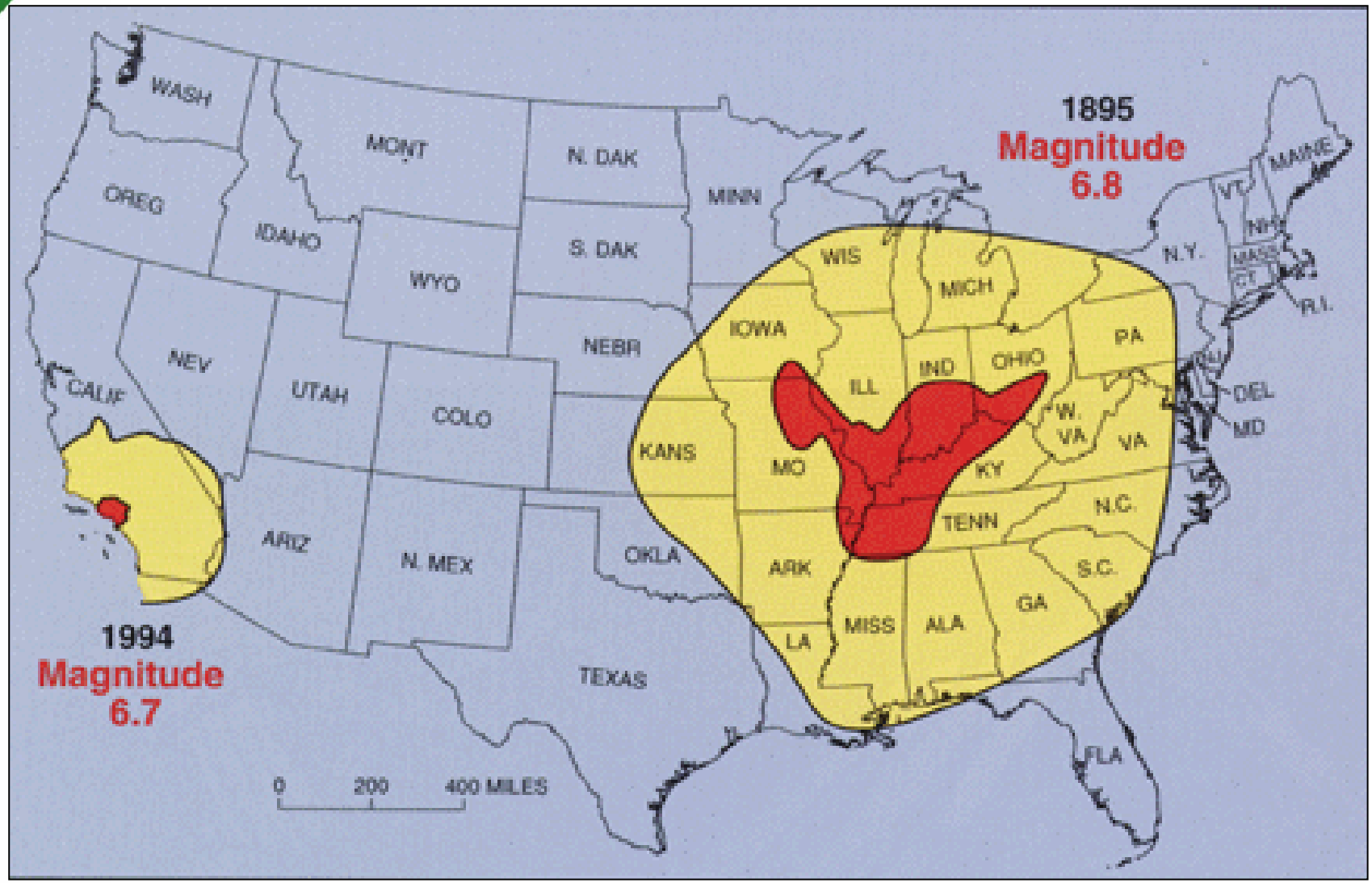

- **Areas affected by earthquakes of similar magnitude – the M6.8 1895 Charleston, MO and M6.7 1994 Northridge earthquakes.**

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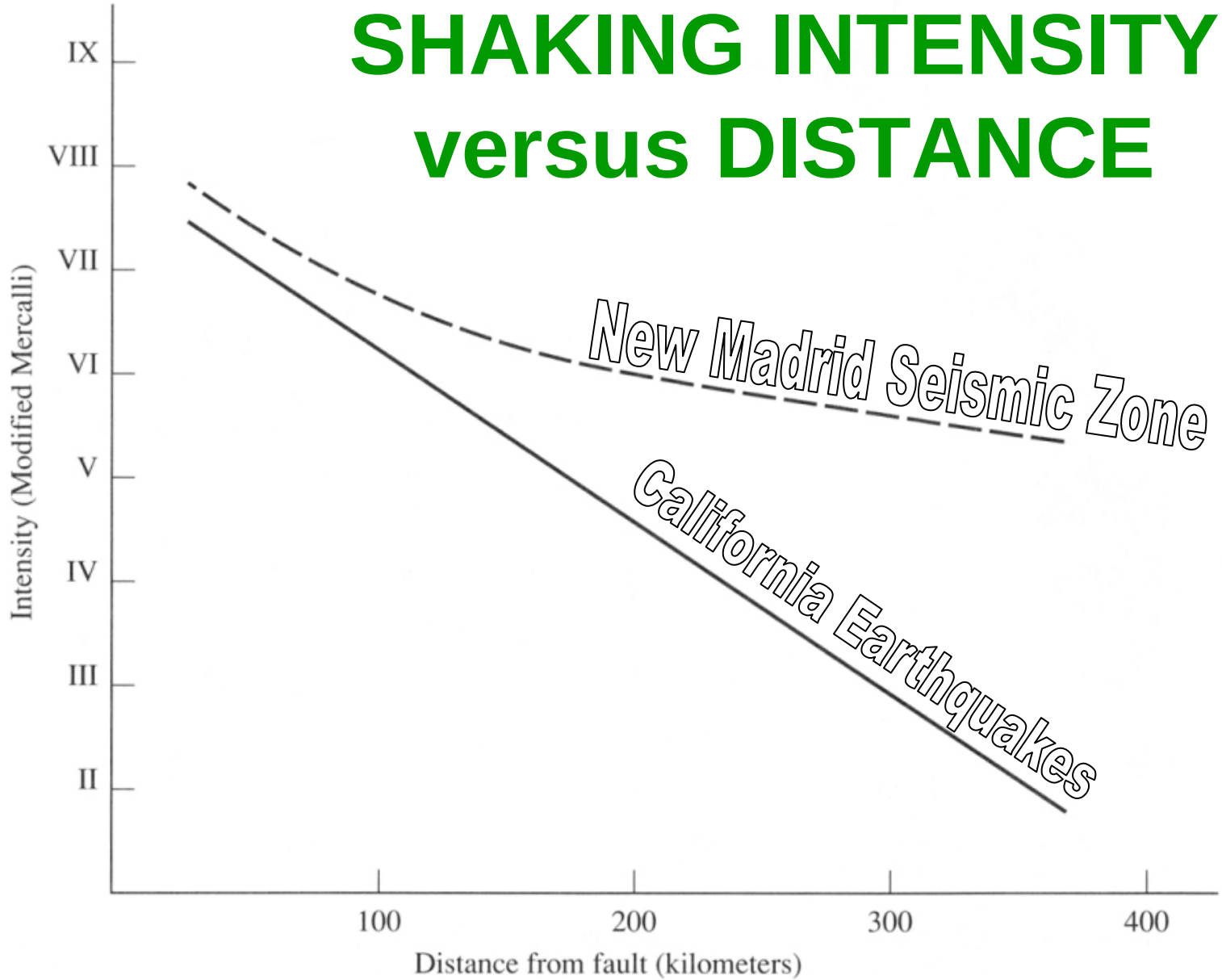
SHAKING INTENSITY versus DISTANCE



Midwest quakes are less frequent, but much more lethal than California quakes because there is <u>less damping</u> of seismic energy.

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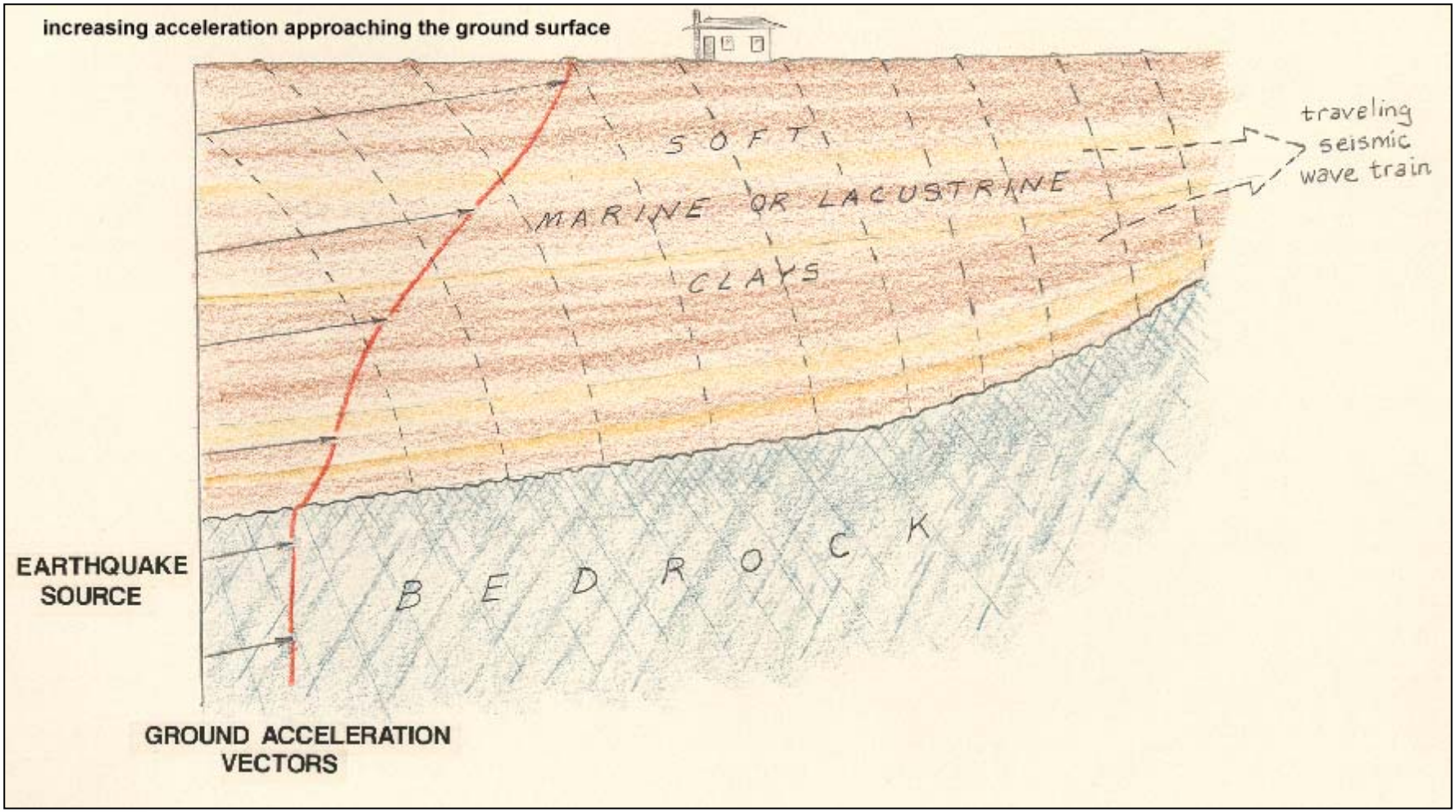
WHAT IS SITE RESPONSE ?



- **Site response is used to describe the fundamental period of vibration generated by a typical earthquake at any particular site. If soft unconsolidated sediments overlie resistant bedrock an impedance contrast develops at this boundary which causes incoming seismic energy to be absorbed at a rate faster than it can be transferred through the upper layers, causing significant amplification of ground motions.**

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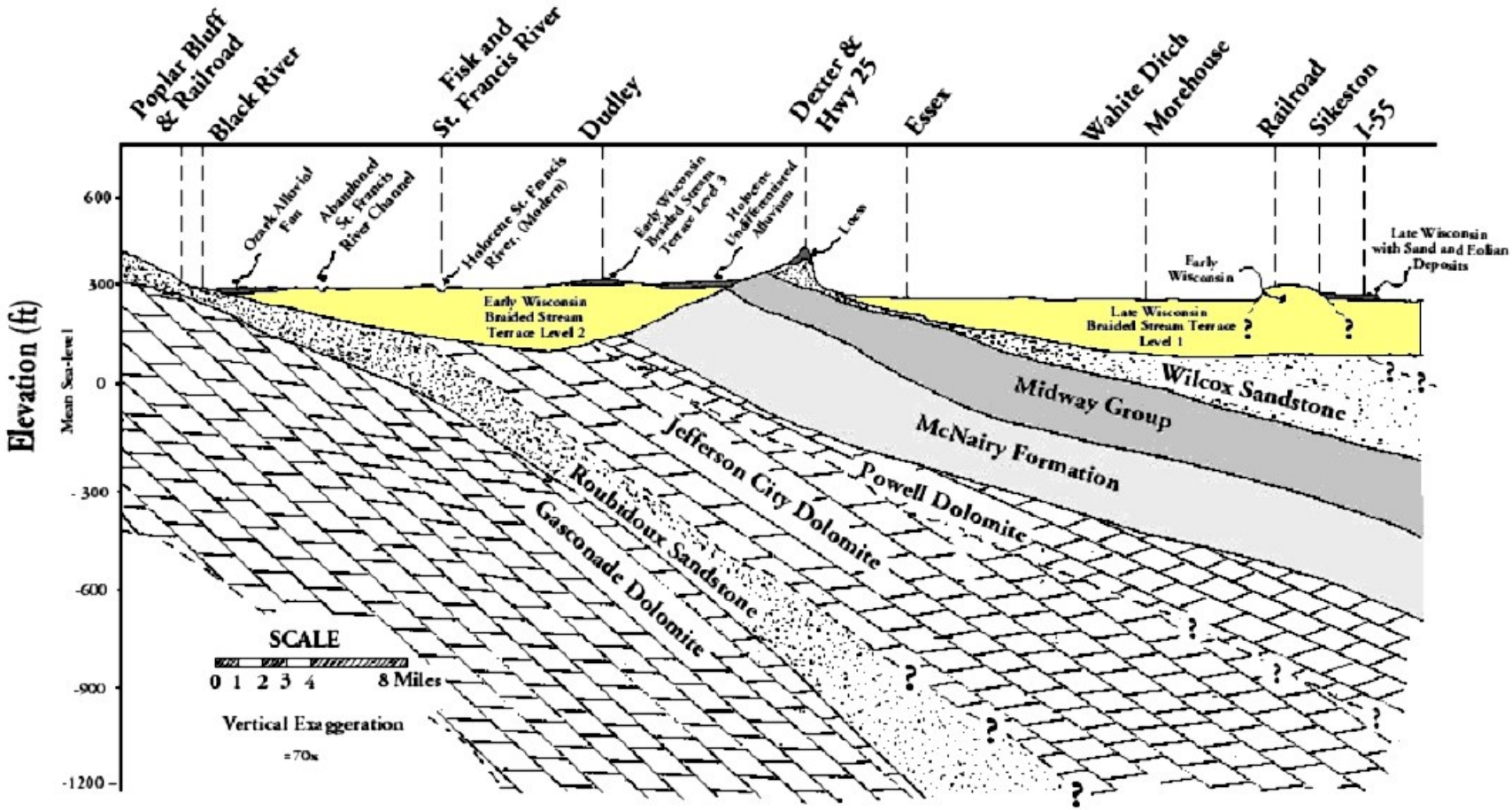
Geology Northern Mississippi Embayment



Impedance contrasts within the Wisconsin age river channels (yellow) likely pose the greatest seismic threat to highway infrastructure in the Midwest.

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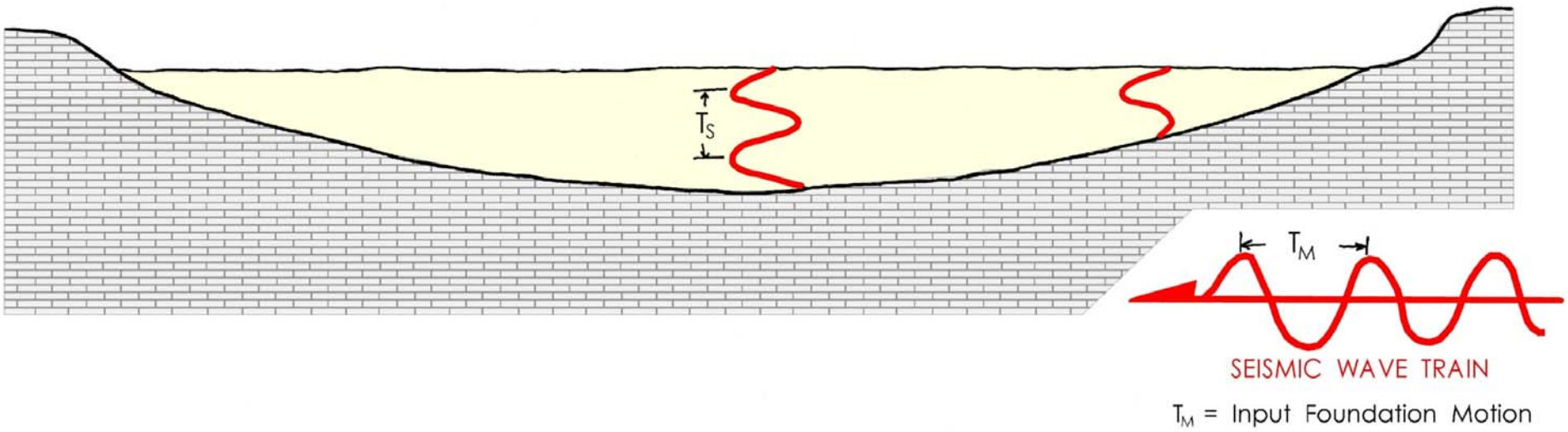
FUNDAMENTAL PERIOD of SAND-FILLED BEDROCK CHANNEL

$$T_S = \frac{4 * D}{V_{S_f}}$$

where

D = depth of channel fill

V_{S_f} = shear wave velocity of channel fill



- **We can estimate the fundamental site period with some basic data. The period will change with location in a parabolic shaped channel.**

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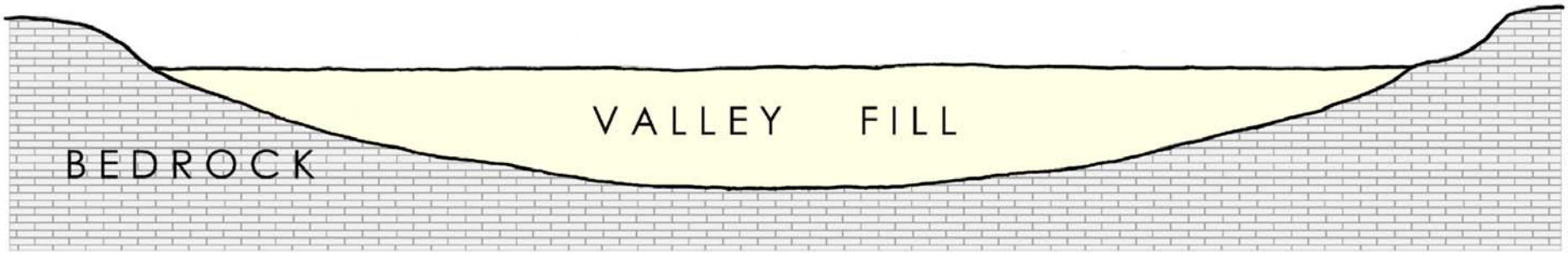
IMPEDANCE



$$\text{IMPEDANCE RATIO} = \frac{\rho_{\text{FOUNDATION}} * V_{S\ \text{BEDROCK}}}{\rho_{\text{VALLEY FILL}} * V_{S\ \text{VALLEY FILL}}}$$

- **Site amplification is a function of the Impedance Ratio between the valley fill and the underlying basement rock. Impedance Ratios in Midwestern US channels are among the most excessive examples identified anywhere in the world.**

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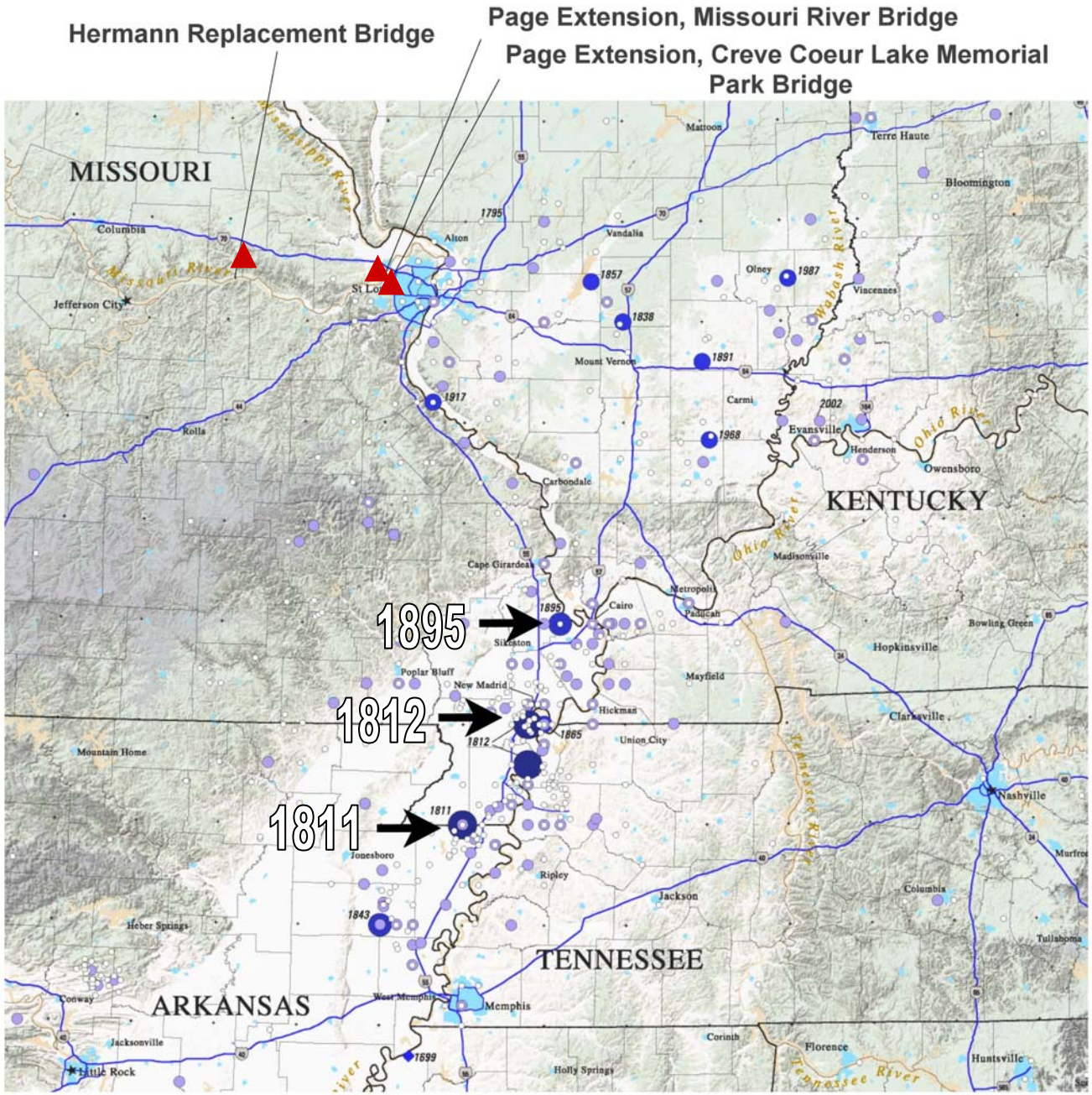
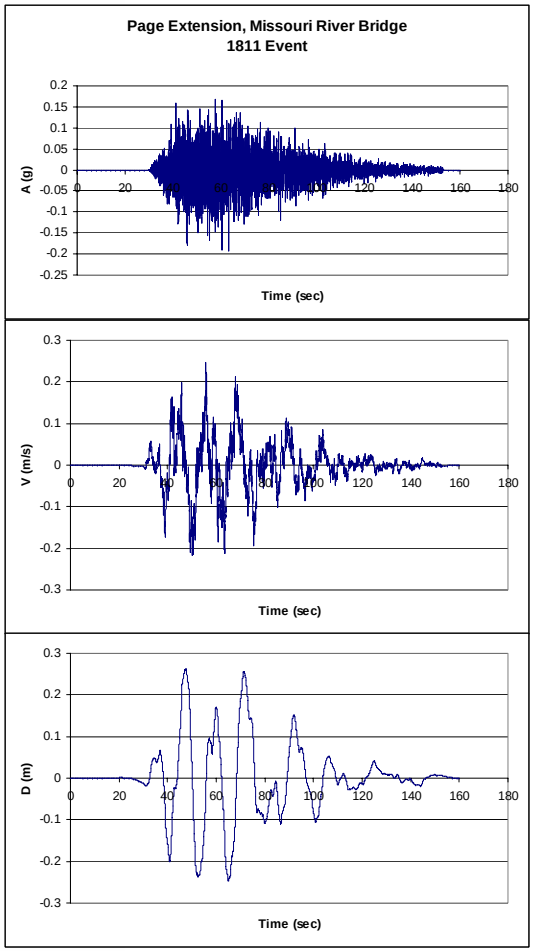
Bridge Locations With Respect to the New Madrid Seismic Zone

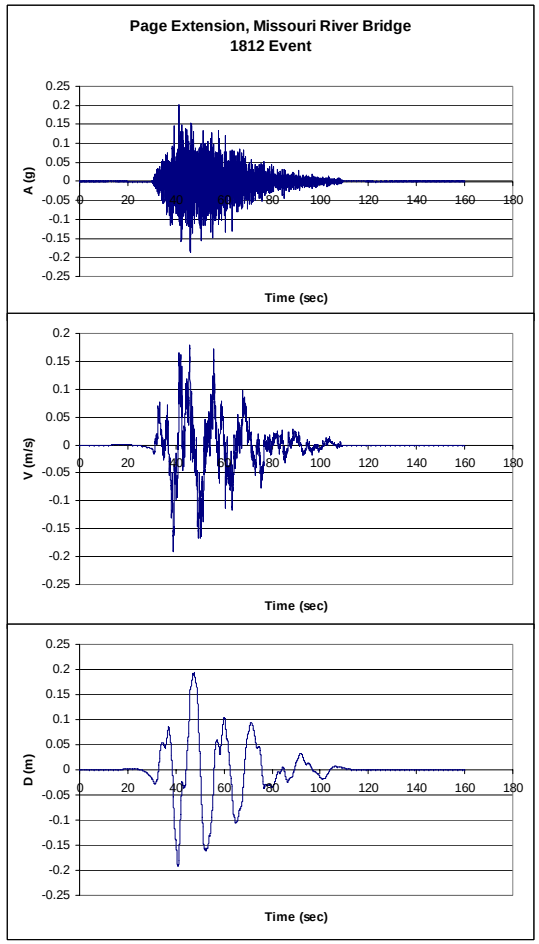


Page Ave. Missouri River Bridge Artificial Time Histories



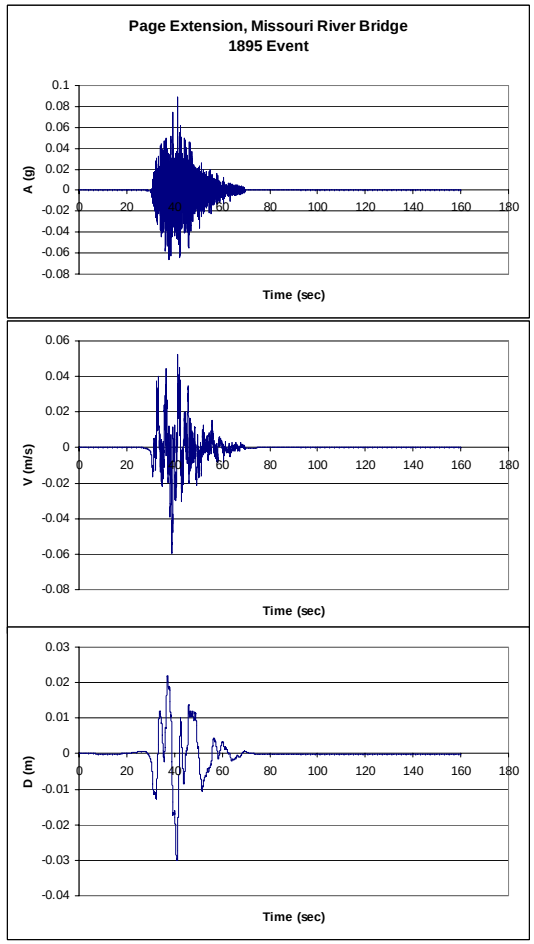
1811

312 km distance



1812

261 km distance



1895

231 km distance

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CONCLUSIONS

- **Multiple earthquake sources within 150 miles of St. Louis Metro Area**
- **Most likely destructive earthquake (25% chance of occurrence in next 50 years) in our lifetimes will be something between Magnitude 6.0 and 6.8, emanating from one of the three source areas**
- **Site amplification likely in deep valley fills, such as Mississippi and Missouri River channels**
- **Widespread liquefaction likely in Magnitude 6.5 or greater events at great range (~150 mi)**

Online Posting

- This lecture will be posted online for easy downloading at:

www.umr/edu/~rogersda/nmsz

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