

Earthquake Hazards & Earthquake Risks in the Central US

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Webinars Hosted by AEG



- **New webinars weekly until Virtual Annual Meeting**
- **On demand**
- **AEG 'online library' for AEG chapters, in lieu of in-person meetings**
- **Variety of subjects**

Phyllis Steckel, RG – Washington, Mo.

- **30+ years in earthquake hazards in CA, WA, UT & MO**
- **Past Missouri Seismic Safety Commission Chair**
- **Worked for Woodward-Clyde, Shannon & Wilson, and EQE International; consultant to USGS**
- ***Sandwich Generation* survivor**

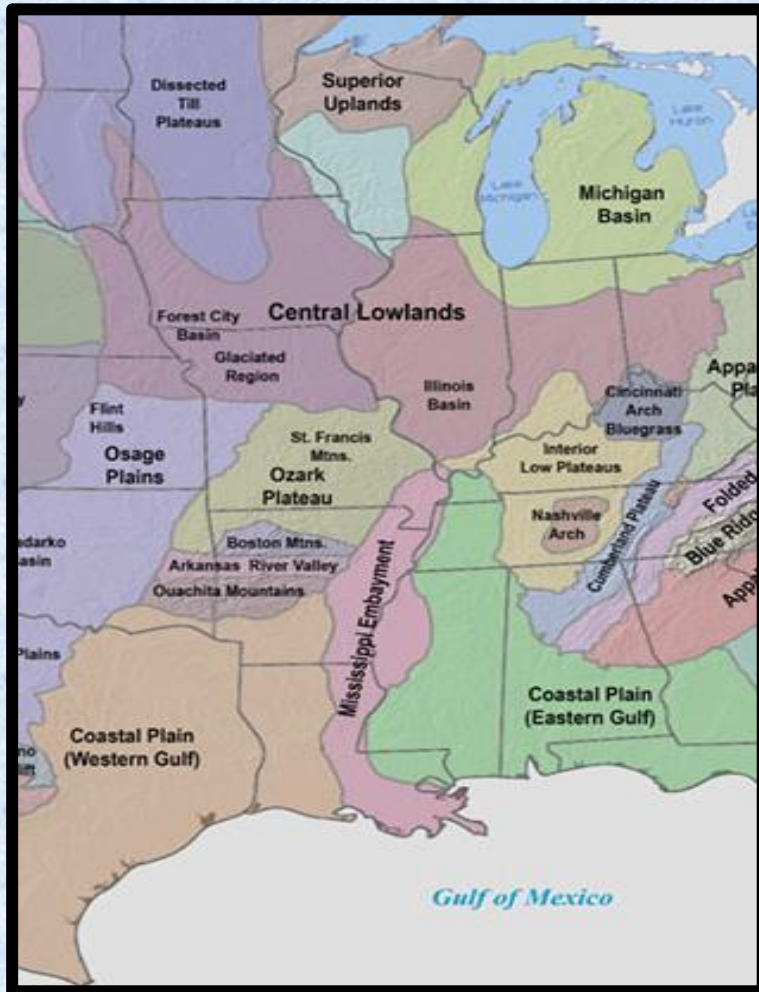


This webinar includes....

- **SETTING:** Regional geology
- **HAZARD:** Earthquake history in central US
- **RISK:** Earthquake exposure in central US
- **ISSUE:** What is being done about it

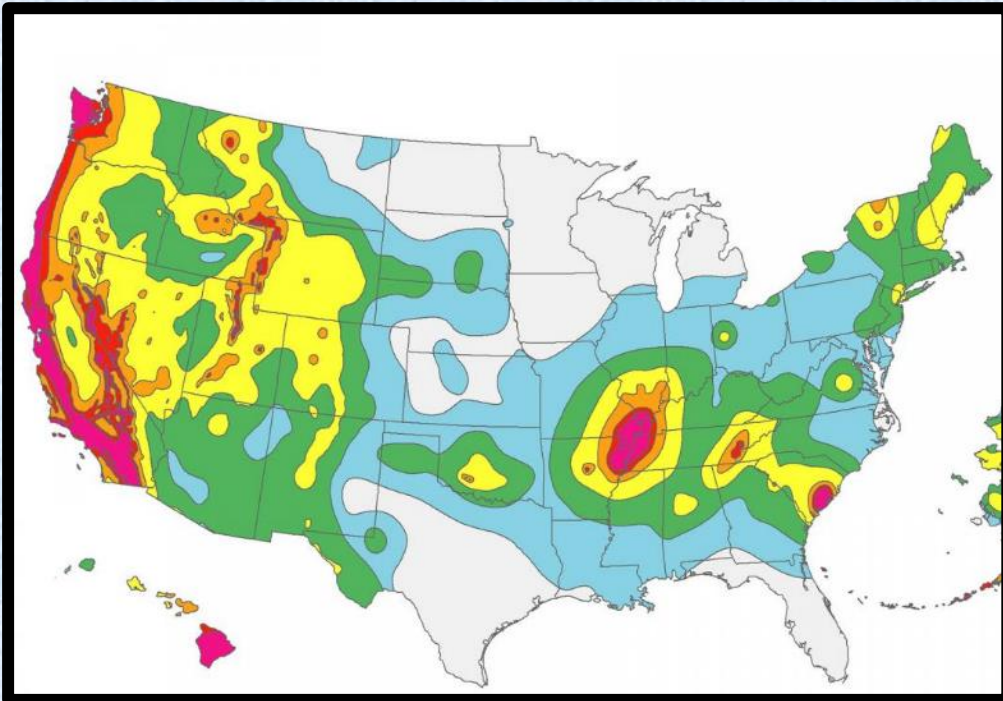


Regional Geology: The SETTING



- Mostly marine sediments: limestones, dolomites, sandstones; some coal
- Fairly flat-lying, some geologic structures
- Eroded remnants of Precambrian in St. Francois Mtns in Missouri

Regional Earthquake Fault Zones



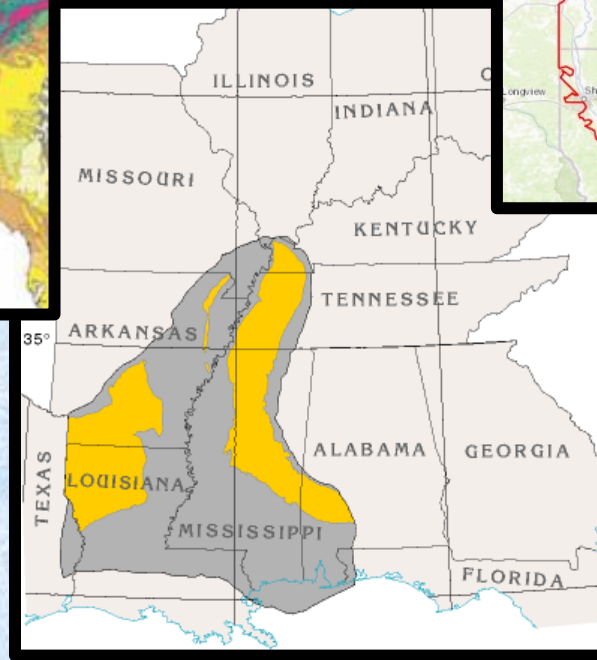
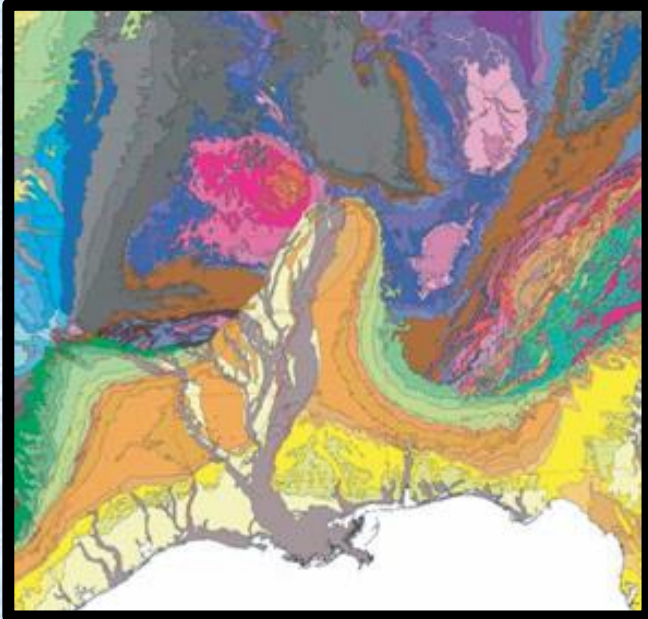
- New Madrid FZ
- East Tennessee FZ
- Wabash Valley (Illinois-Indiana)
- Humboldt FZ (Kansas)
- Illinois Basin
- Oklahoma: natural & man-made
- Anna and Toledo, Ohio; Aurora, Ill.; Ste. Genevieve, Mo. *+more*

Mississippi Embayment

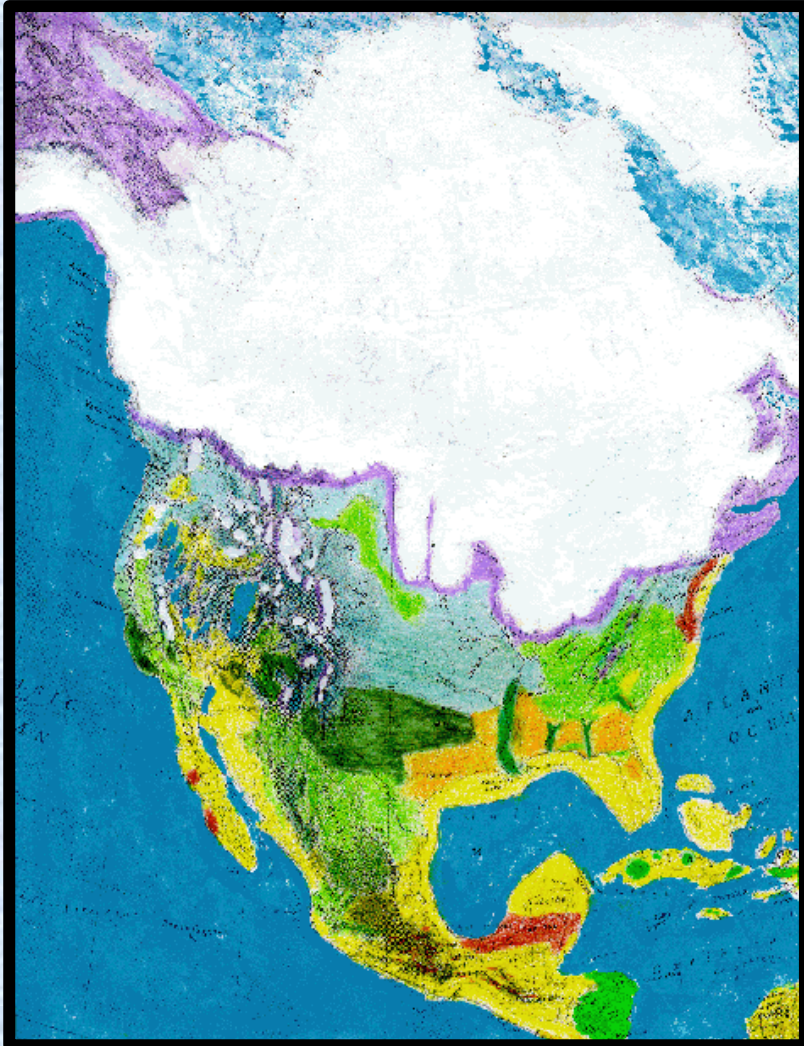


- Episodic active structures since Precambrian
 - Reelfoot Rift
 - Break in Appalachian-Ouachita range
- Axis near and parallel to Mississippi River
- Deepens and widens to the south

Mississippi Embayment



Continental Glaciation



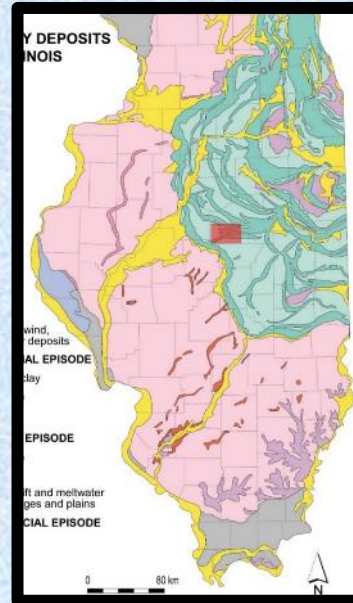
- Many pulses of continental glaciation
 - Glacial sediment moved downstream
 - Choked Mississippi, Missouri, Ohio, Illinois, Kansas, & Arkansas rivers
- Glacial meltwaters scoured deep river valleys during high flow
 - Naturally braided streams
 - Underfit (!) streams now

Mississippi Embayment Sediments

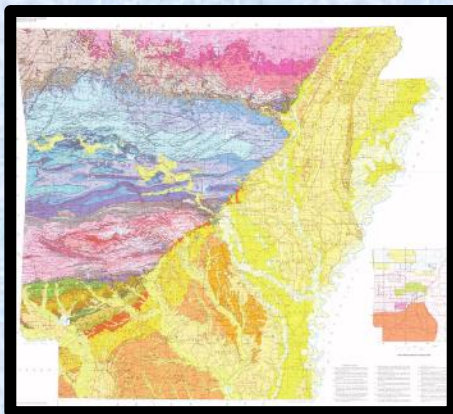
- Big Rivers eroded glacial debris and transported it downstream
- Bedrock 100'+ deep in big-river floodplains
- Bedrock 1000'+ deep in Mississippi Embayment
- Deposited in 'Mississippi Delta' – local term for area



Surface Geology



- Yellow areas on map:
 - Alluvial valleys
 - Glacial lake deposits
 - Mississippi Delta
- Thicker alluvium = more intense earthquake shaking



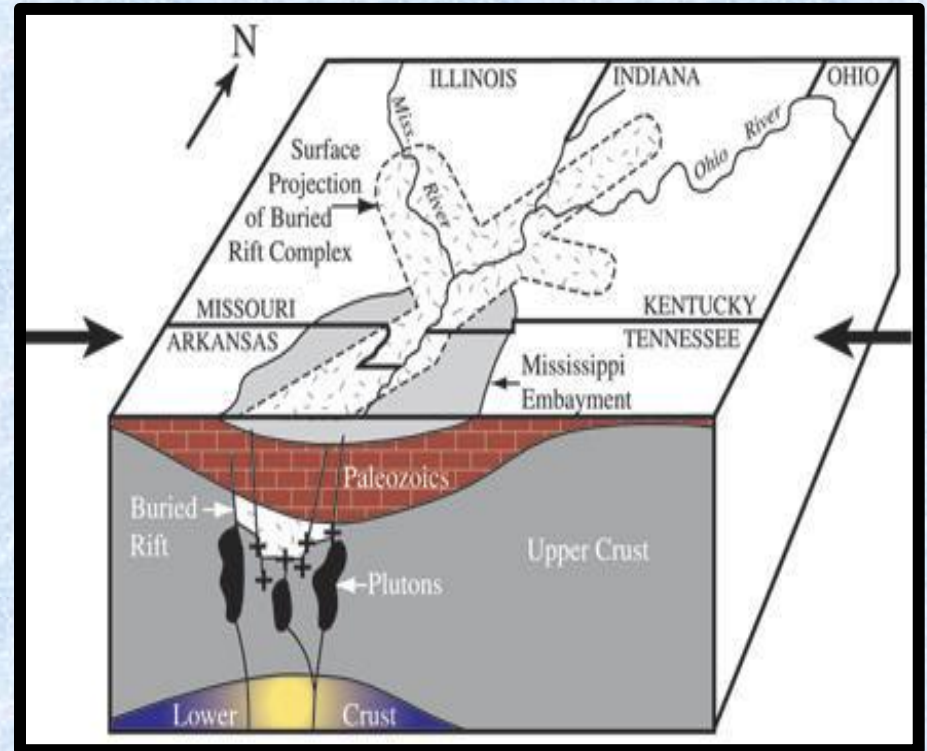
Hazard & Risk – in this Webinar

- **HAZARDS** are geologic processes or events
 - Earthquakes, landslides, liquefaction, tsunami, etc.
- **RISKS** are losses or damages from geologic hazards
 - Loss of life, property, income, equity, value, market share, community, etc.

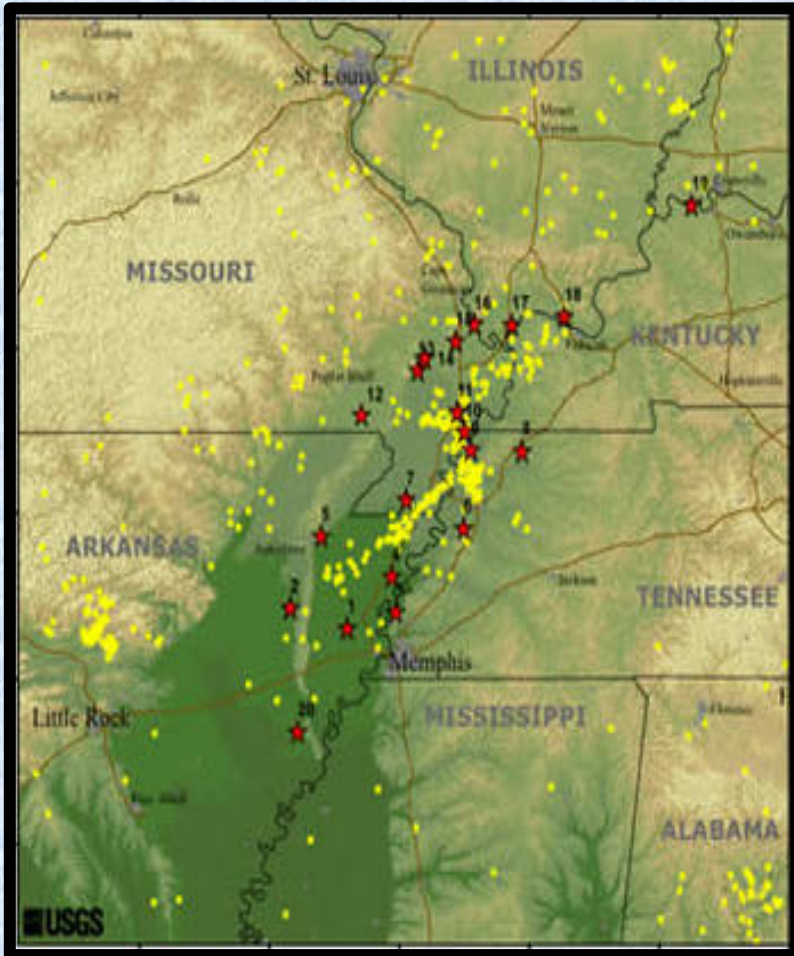


New Madrid Fault Zone: The HAZARD

- In the northern part of Mississippi Embayment
- Buried under several thousand feet of loose sediments, thicker to the southwest
- Active episodes for 100,000,000+ years; old plutons, rifts, grabens

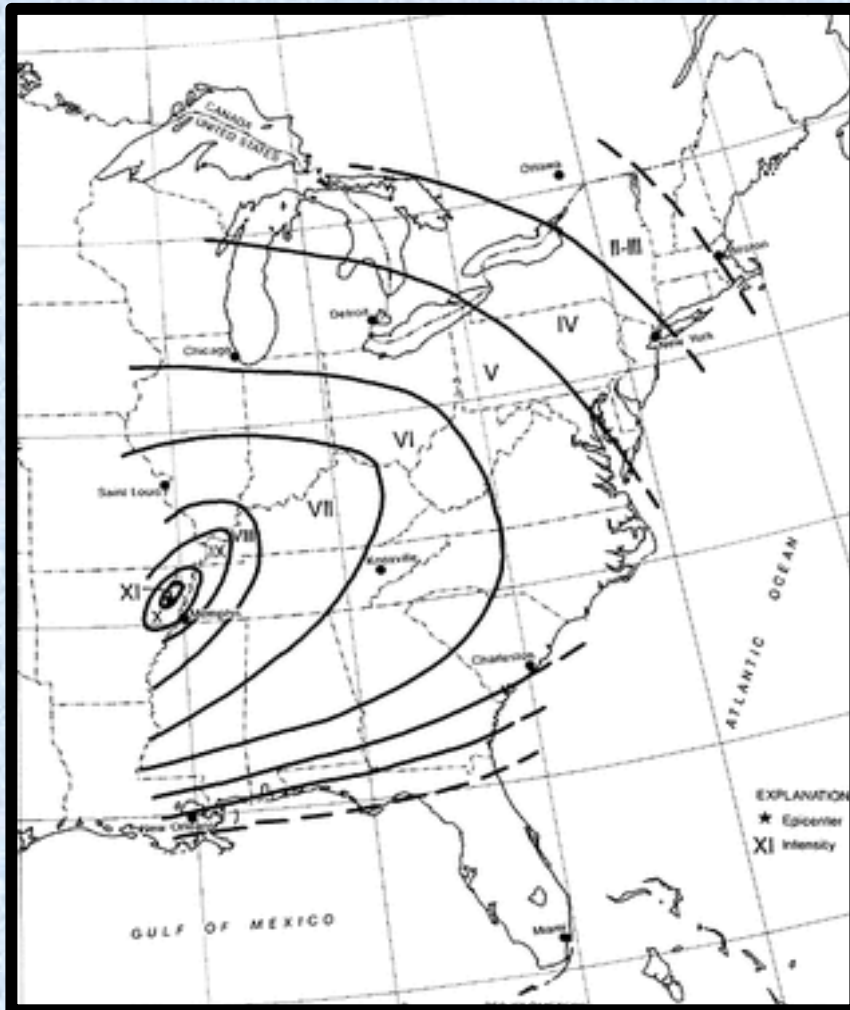


New Madrid Fault Zone



- Active today
- Most earthquakes <mag 3 and 10-20 km deep
- ‘Double dog-leg’ of strike slip and thrust
- A fault zone not a plane
- NE Arkansas, SE Missouri, S Illinois, W Tennessee & W Kentucky

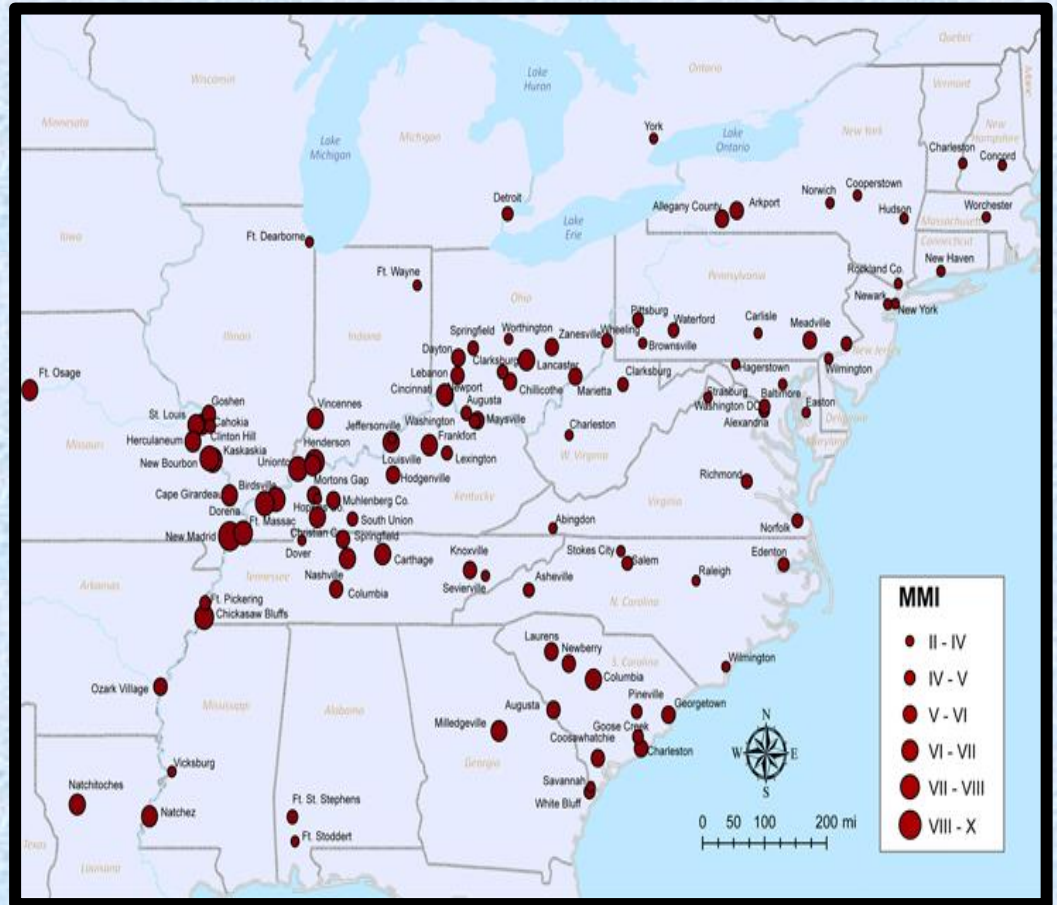
New Madrid 1811-12 Earthquakes



- Dec 16, 1811; Jan 23 & Feb 7, 1812
- Each mag 7+
- Many aftershocks!
 - Dr. Jared Brooks of Louisville, Ky. noted more than 2,000 felt earthquakes (300-400 km from epicenters) until May 1, 1812

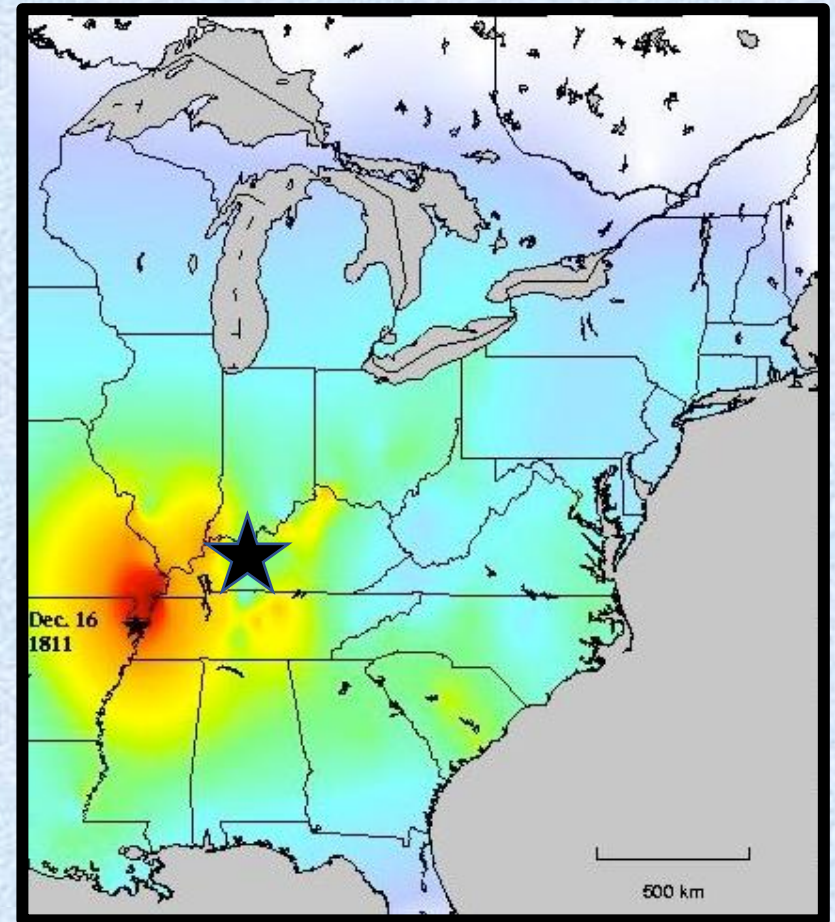
1811-12 Felt Reports

- Shaking intensity higher along rivers
- Population located along rivers
- Most people could not read or write
- English-speakers only (French, Spanish, & Native accounts not included)



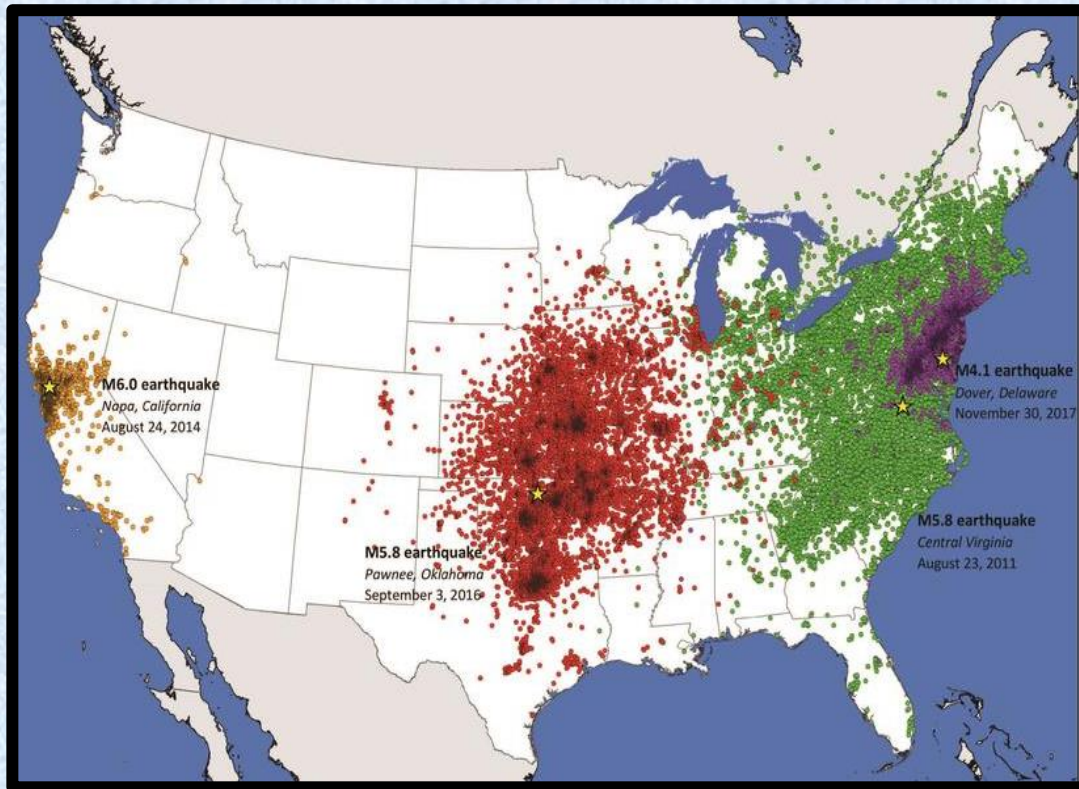
IDEA: Research Abraham Lincoln's felt report?

- Born February 12, 1809 near Hodgenville, Ky.
- Abe was almost 3 years old in 1811-12
- Neither parent could read nor write
 - Neighbors' reports?
 - Sinking Spring Farm?
- Lincoln family moved within a year....?



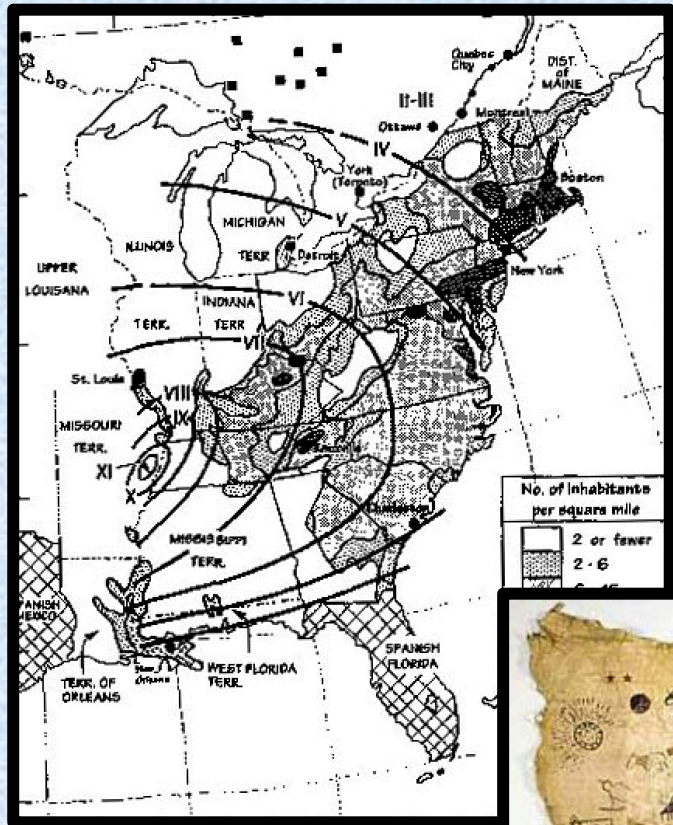
Earthquake Felt Reports

California – Central US – Eastern US



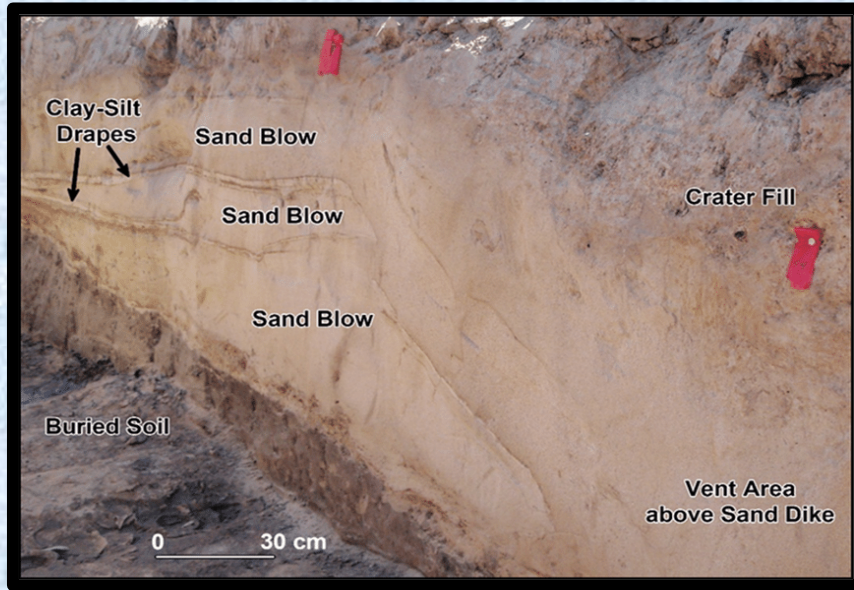
- **Mag 6.0 Napa, CA (2014)**
- **Mag 5.8 Pawnee, OK (2016)**
- **Mag 4.1 Dover, DE (2017)**
- **Mag 5.8 Central VA (2011)**

Idea: Research Non-English Sources

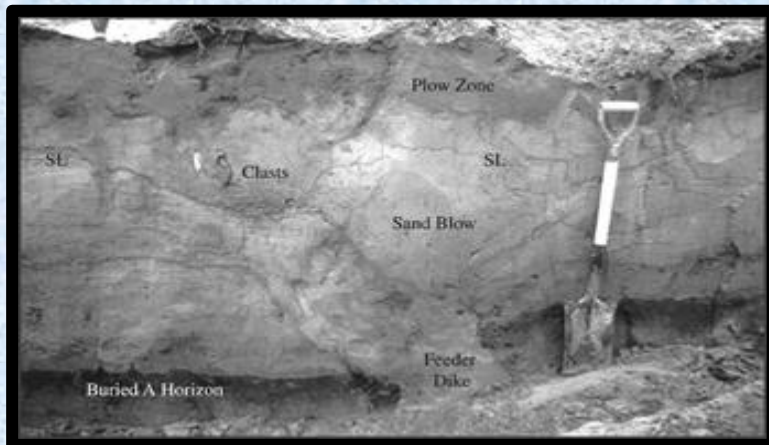


- Spanish-speakers lived in northern Florida, Texas, and New Mexico
- French-speakers lived in Louisiana, Quebec, and northern Great Plains
- Native Americans recorded on *winter counts* (hides that noted major annual events)

Geologic History of New Madrid



- Liquefaction results in sand blows
- Paleoseismic history can be seen in sand blow record
- Previous series ~1450 and ~900 CE and ~2300 BCE
 - Shows multiple, large earthquakes in each series

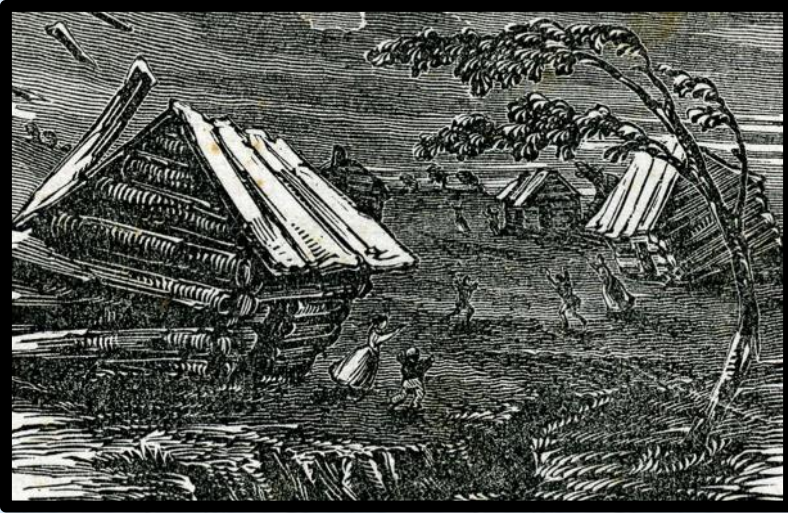


What happened in 1811-12?

- Epicentral area devastated
- Reelfoot Lake created
 - Uplift 'dammed' Mississippi River; diversion flooded lowlands = Reelfoot Lake
- Mississippi River 'flowed backwards'
- Landslides along the Chickasaw Bluffs



Effects of 1811-12 Earthquakes



- Epicentral area devastated
 - All structures demolished
- Local topography changed
 - Dry land sank
 - Channels and lakes uplifted
- Landslides along uplands, lateral spreading into Mississippi River
- Damage in St. Louis; Louisville; Annapolis, Md.+

Effects of 1811-12 Earthquakes

- Mississippi River channel choked with slumps and debris: impassable
- ‘Continuous’ aftershocks for months
- Landslides and lateral spreading – crevasses later used by troops in Civil War

(Photo from Fuller, 1912)



Effects of 1811-12 Earthquakes



- Eliza Bryan wrote detailed account in 1816
 - ‘Violent shocks...’
 - ‘Continuous agitation...’
 - ‘Sand...from fissures...’
 - ‘Twenty-foot waves...’
- Evidence still visible today
- Lived to age 86; buried in New Madrid

Effects of 1811-12 Earthquakes

- President James Madison awakened by several New Madrid earthquakes *at the White House*
- William Clark (Lewis & Clark) convinced federal govt to assist: \$50K relief
- Most residents left → 160+ acres elsewhere in Missouri



New Madrid Fault Zone: The RISK

- 200+ years of development & population growth
- Many equity owners are remote
- Few 'reminders'
- Forgetful leadership



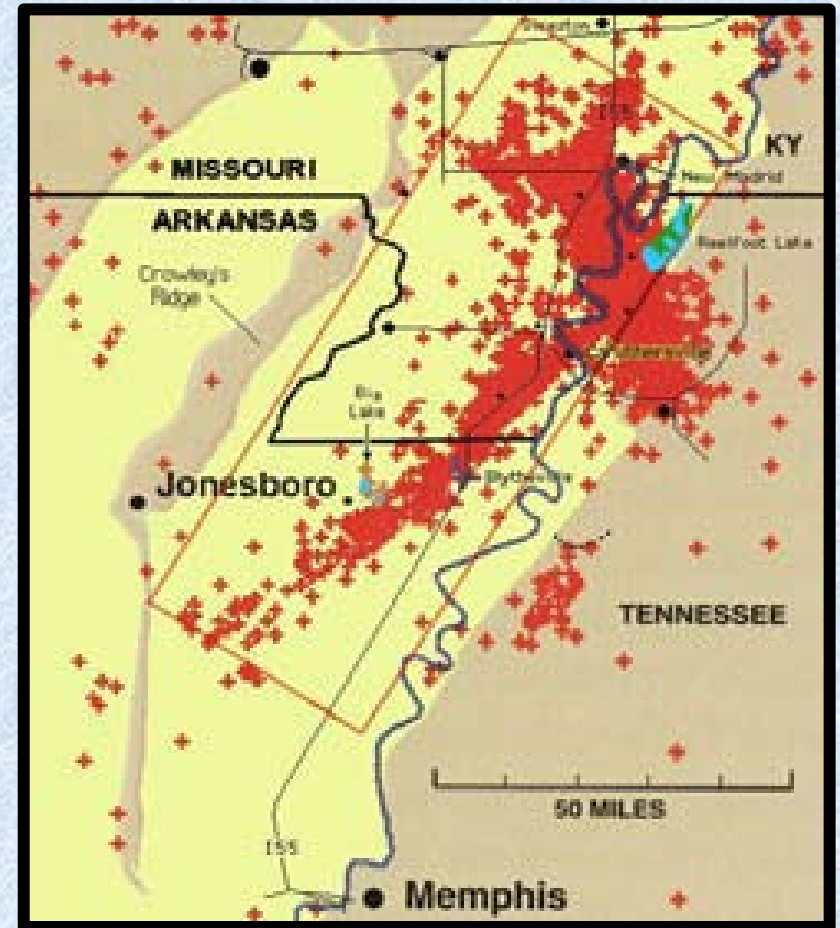
What's at risk?



- **People & personal property**
- **National systems: highway, rail, river, and air transport**
- **Steel industry**
- **Pipelines serving the Northeast**
- **Intense agricultural production**
- **Primary minerals processing**

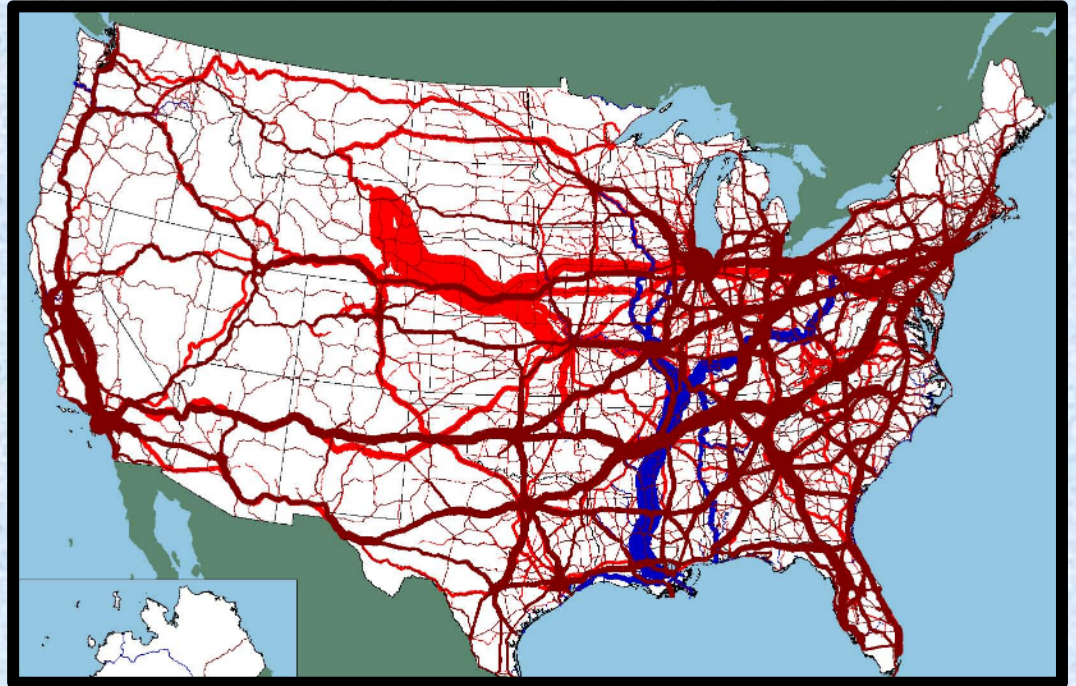
People

- Nearly 1,000,000 people in epicentral area (incl Memphis, Tenn.)
- Building codes do not always include seismic
- Some rural areas have no codes at all (not even fire)

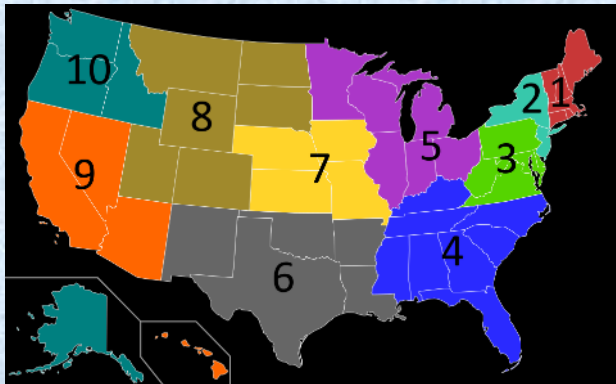
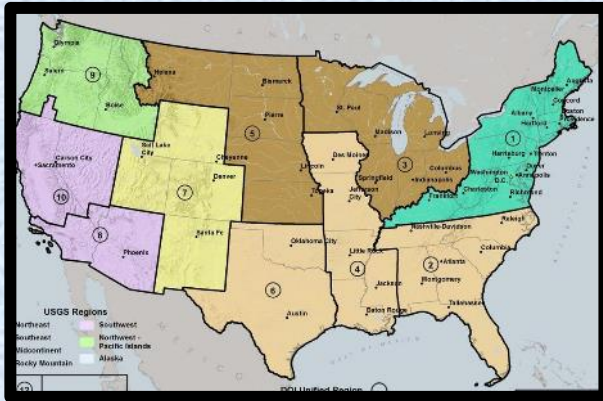


National Transportation System

- Highways, inland waterways, pipelines, and railroads
- ‘Choke point’ in New Madrid area
- “Crossroads of US”



In the 'Corner' of Many Jurisdictions



- Eight states
- Seven USACE Districts
- Four FEMA Regions
- Four USGS Regions
- Complicated administration!

Riverside Industries at Risk

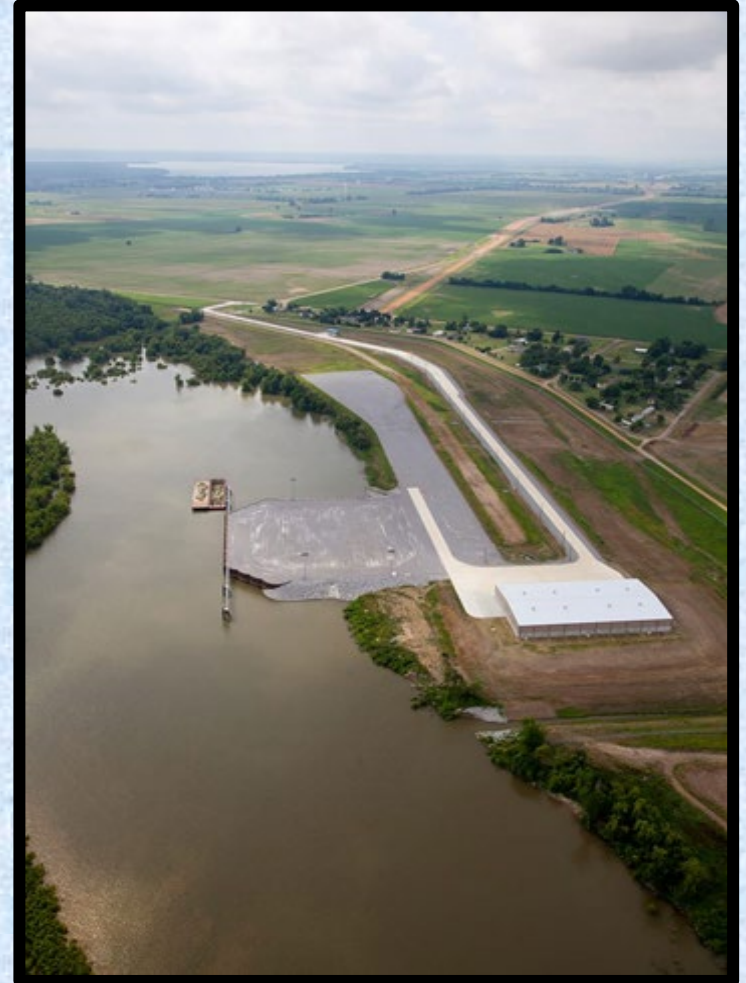


- ‘Magnitude 7 Metals’ in New Madrid – aluminum processor
- Commodity logistics
 - Grain
 - Salt
 - Ore
 - Recycled metals
 - Coal+



Riverside Industries at Risk

- **Far NW corner of Tennessee:
Cates Landing Terminal:
*“...suited for manufacturing
industries, warehousing, and
distribution center ops...”***
- **Cates Landing Terminal has
been built into the slope
created by the 1811-12
earthquake scarp**



Steel Industries at Risk



- **Mississippi County, Arkansas, is 2nd largest steel-producing county in the US – lots of robotics!**
- **Raw materials and products come and go via Mississippi River**
- **Finished products (coil, structural steel+) sold to US & international market**

Agricultural Production at Risk

- Land surface is naturally a poorly drained swamp
- Engineered drainage systems, begun in early 1900s, allowed large-scale agriculture – fertile!
- Future earthquakes will interrupt engineered drainage flow



Air Freight Systems at Risk



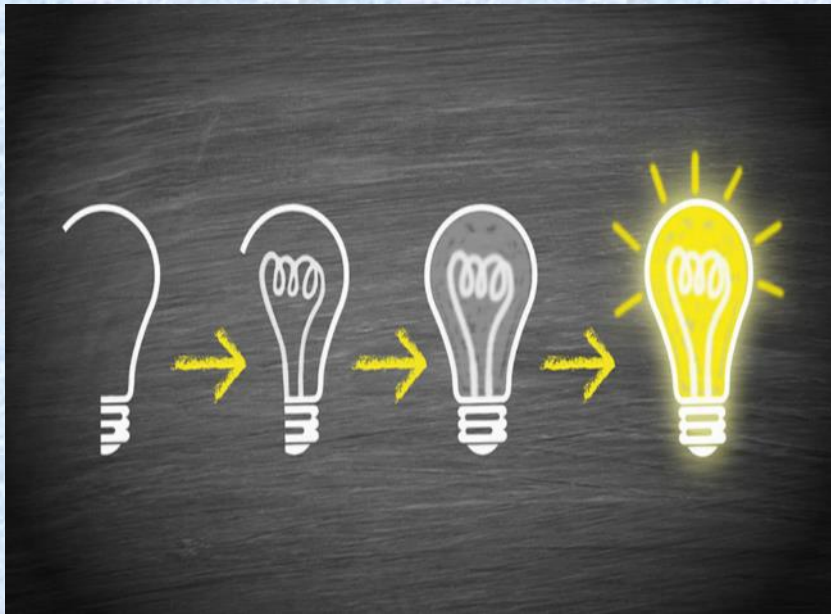
- Memphis is busiest cargo airport in North America; second busiest in the world
 - FedEx and UPS
- 12,000+ direct employees; 24/7 operations
- Consumer products can ship in a few hours
 - Meds, small appliances, shoes, surgical supplies

Logistics Industries at Risk



- Memphis integrates rail, port, highway, air transportation systems
- Manufacturing, corporate, and buyers are not local
- Products are *stored* in Memphis (mostly tilt-up warehouses) until shipped
- ‘Unnatural concentration’ of US inventory in Memphis

Takeaways from this Talk....



- Significant earthquake hazards in the Central US
- Low-probability, high-consequence event
- Mitigation is spotty, at best
- New Madrid is not just a 'local' earthquake hazard: the consequence will affect the US and beyond

2021 Earthquake Insight Field Trip

- Begun in 2005 for USGS, via NEHRP, then volunteer
- April 16-18, 2021 (Covid-19 dependent)
- Four states, 500 miles, 48 hours, ~20 stops
- CEUs/PDHs available
- psteckel@charter.net for information

