BRIEF OVERVIEW OF

SEISMIC HAZARDS FOR THE ST. LOUIS METROPOLITAN AREA

for

New Madrid Chapter

Earthquake Engineering Research Institute

Metropolitan St. Louis Seismic Design Symposium

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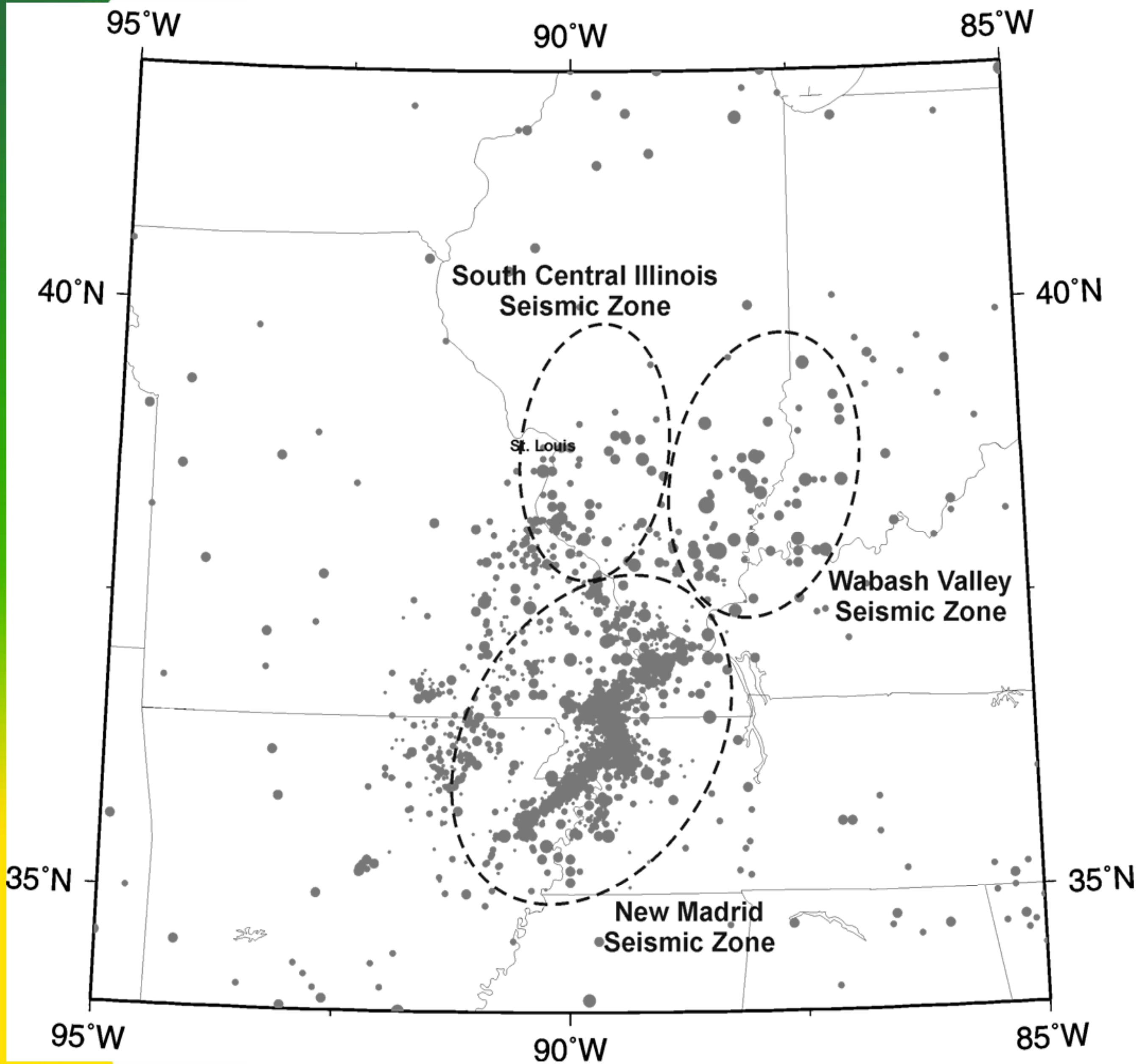
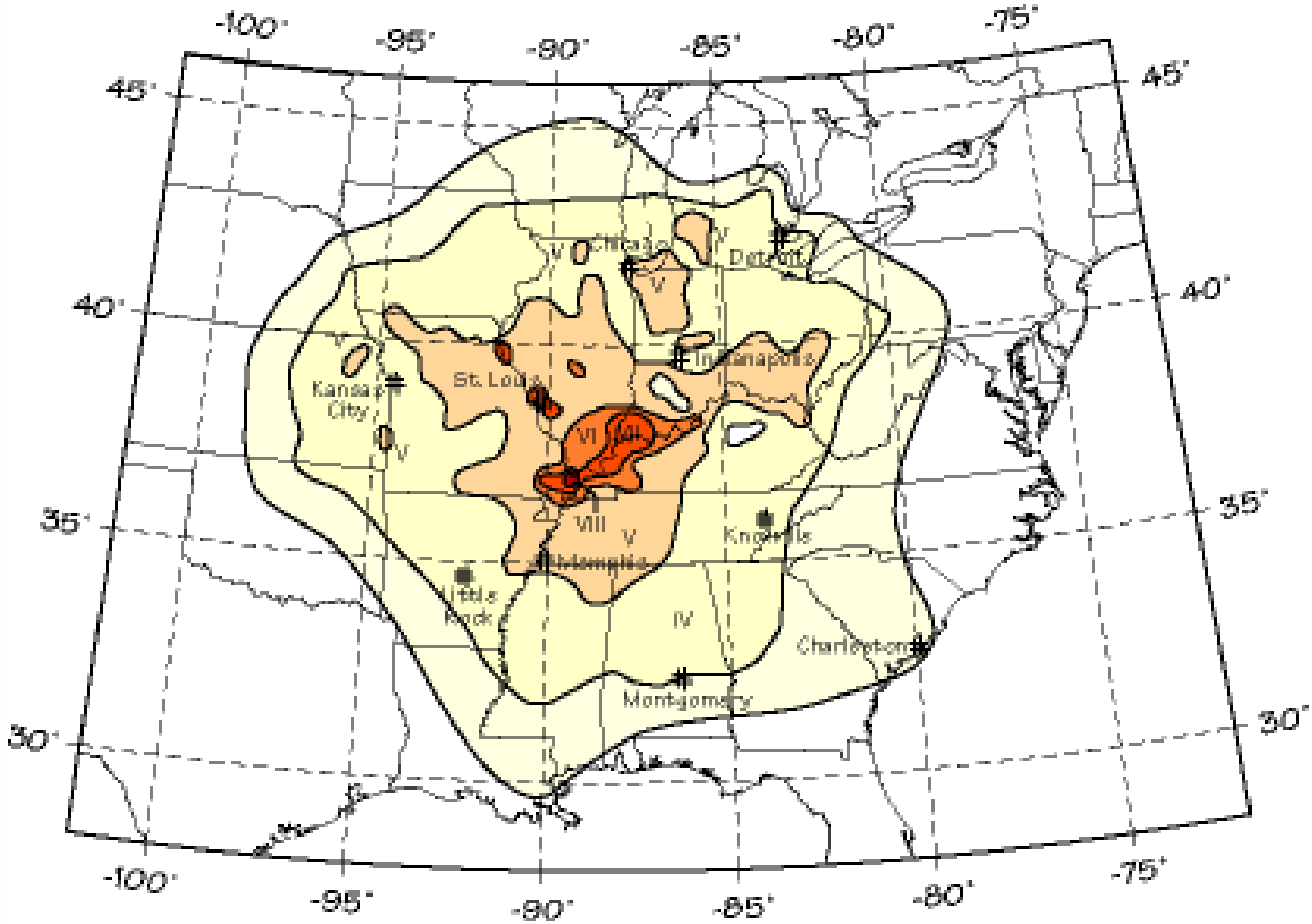
Active Midwest Seismic Zones



- New Madrid Seismic Zone rediscovered in 1973 NRC study of West Memphis power plant
- Wabash Valley Seismic Zone generated M 5+ quakes in 1968 and 1987; initially suspected in 1993 and accepted in 2004
- South Central Illinois spawned a M 5+ quakes in 1838, 1857, and 1891. Initially recognized in 1999

Earthquake Shaking Intensity Map



The 1895 M6.0 Charleston, MO earthquake affected an area 20X greater than an equivalent magnitude quake in California

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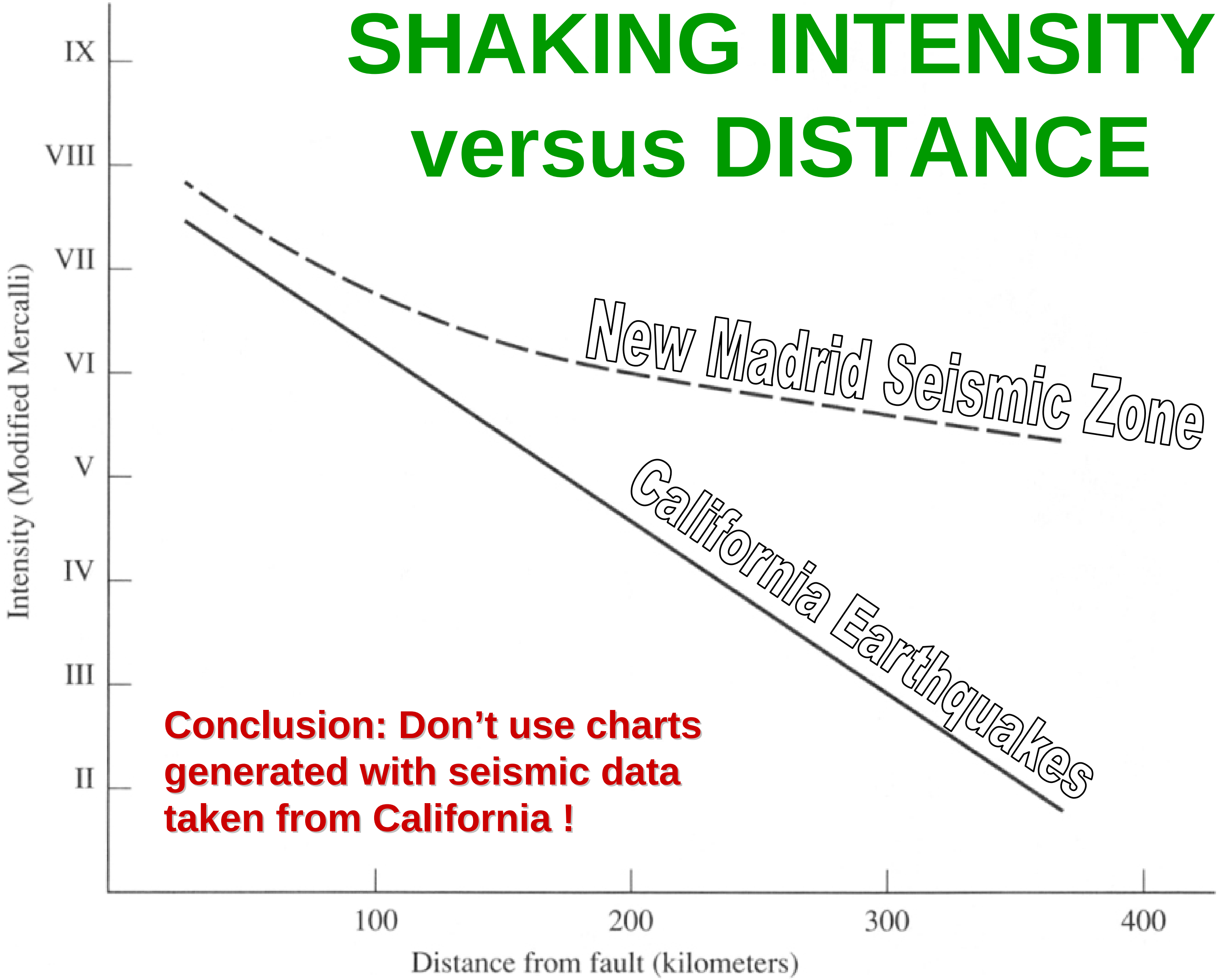
SHAKING INTENSITY versus DISTANCE



Conclusion: Don't use charts generated with seismic data taken from California !

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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Recurrence Intervals for New Madrid Earthquake Events*

Magnitude	Recurrence Interval
4.0	14 Months
5.0	10 – 12 Years
6.0	70 – 90 Years
7.0	254 – 500 Years
8.0	550 – 1200 Years

* based on existing data; always subject to update and revision

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MOST LIKELY QUAKE

- In our lifetimes, the most likely earthquake to impact St. Louis would be something similar to the Magnitude 6.0 Charleston, MO quake of 1895, which has a recurrence frequency of 70+/- 15 years (overdue since 1980).
- It could emanate from either the New Madrid Zone or the Wabash Valley Fault Zone, or from South Central Illinois.

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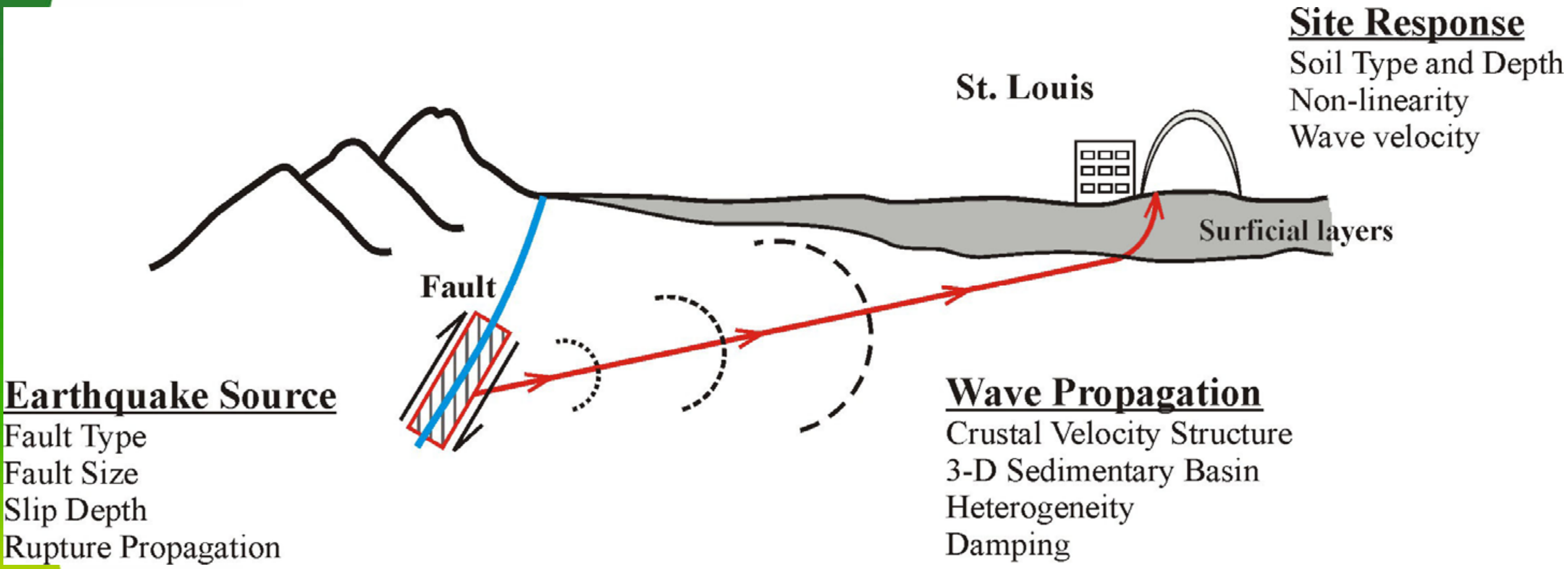
What is Site Response?



The type, depth and size of fault, combined with physical properties of crust and geophysical properties of overlying surficial soils combine to affect site response.

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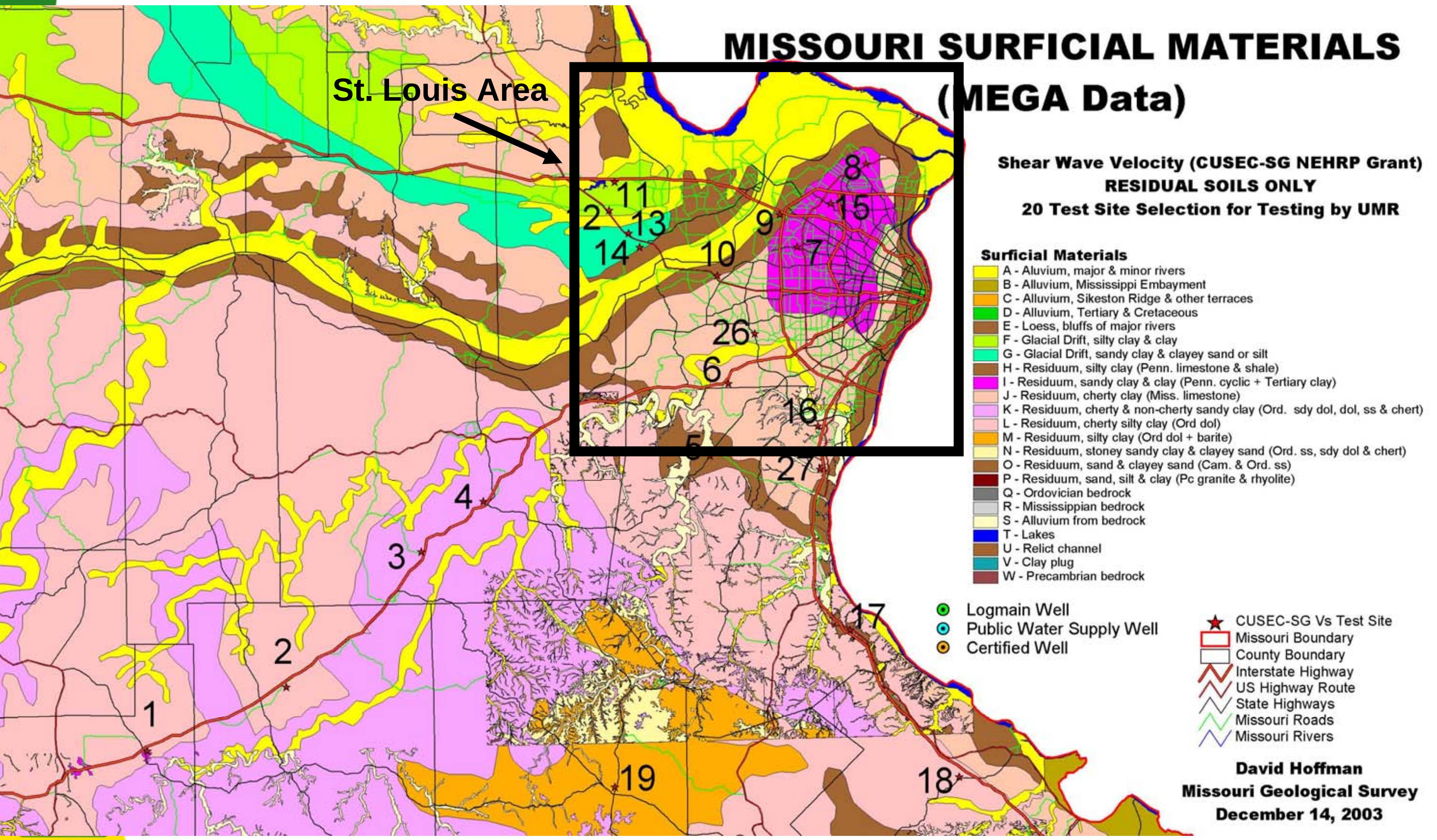
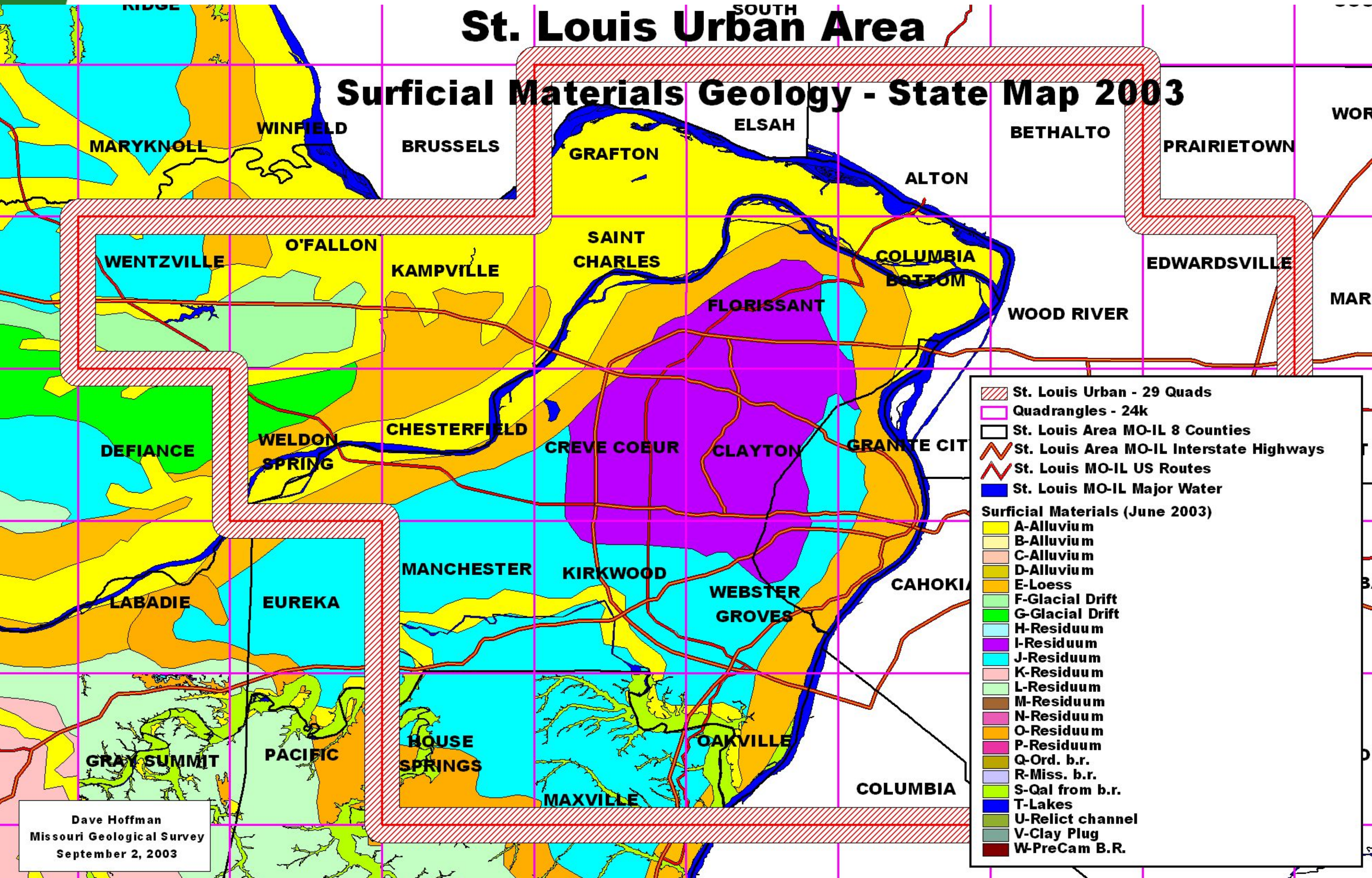
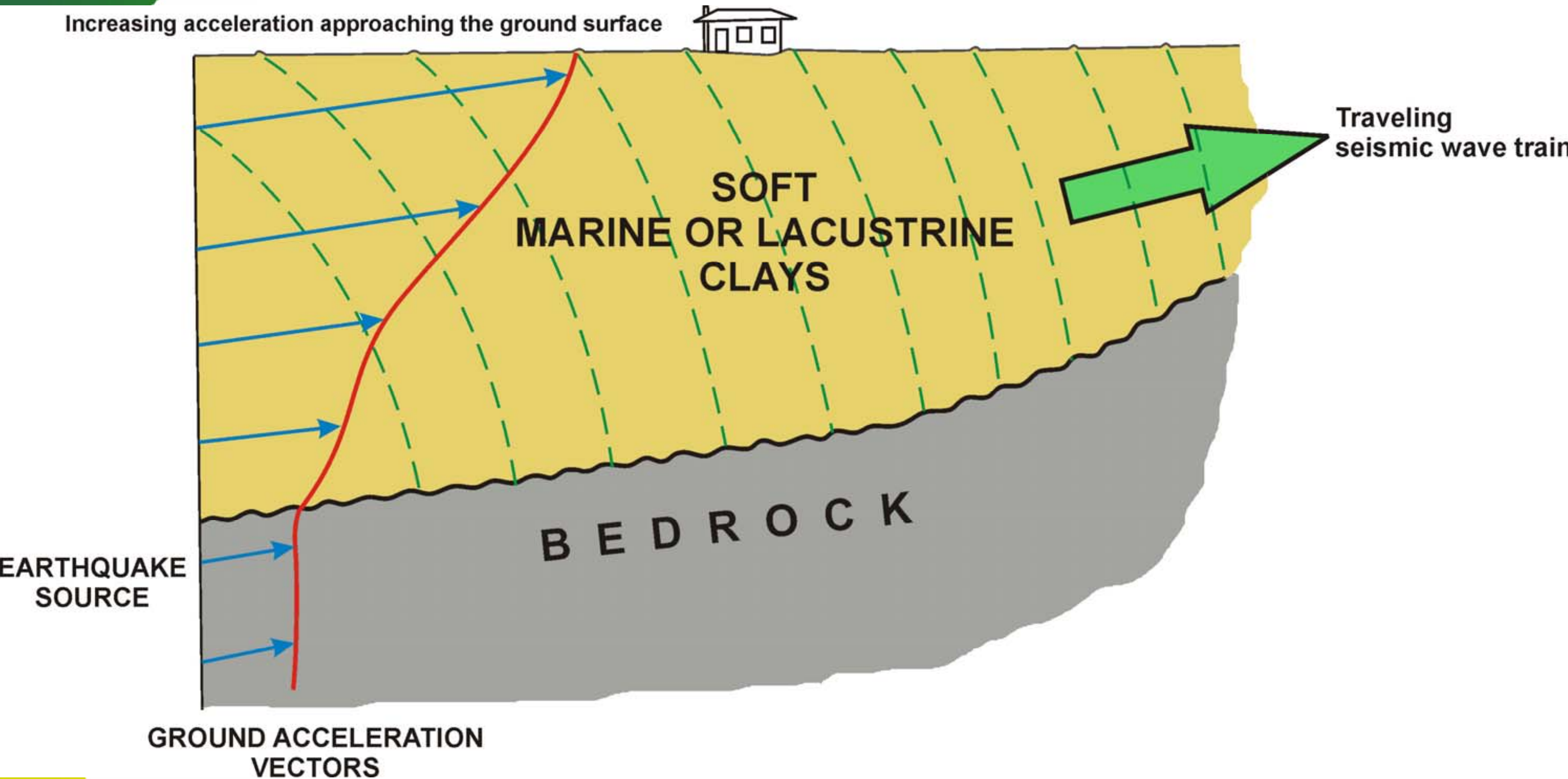
Surficial Geologic Map of Eastern Missouri



USGS-NEHRP St. Louis Metro Area Study





Site response is used to describe the fundamental period of vibration and lateral forces generated by a typical earthquake at any particular site.

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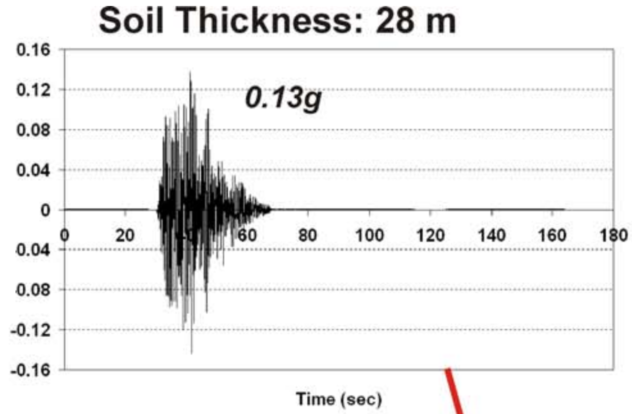
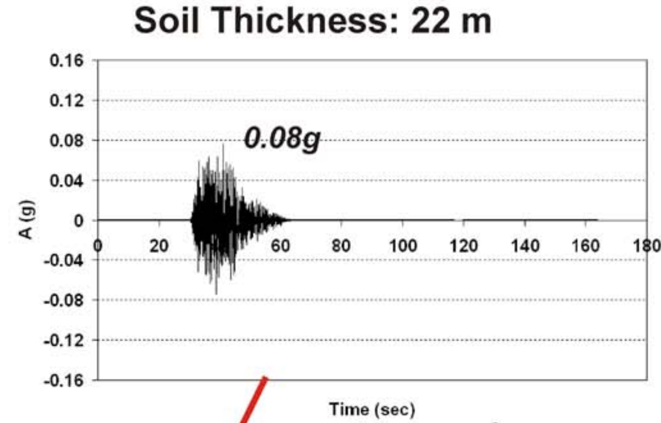
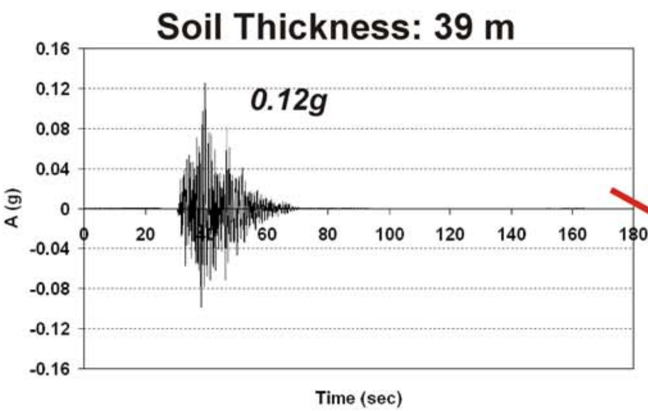
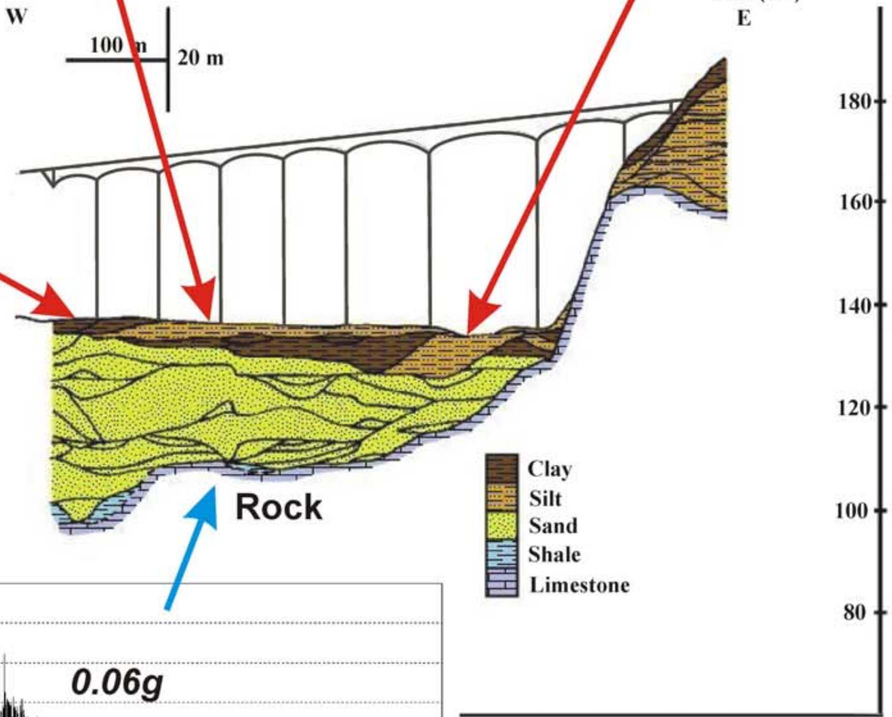
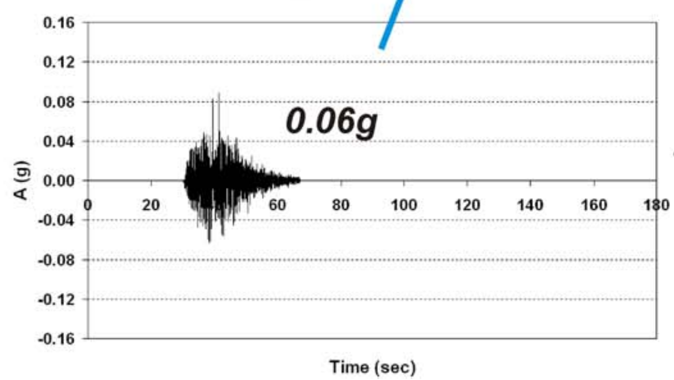
Effect of Soil Thickness on Peak Ground Acceleration (PGA)







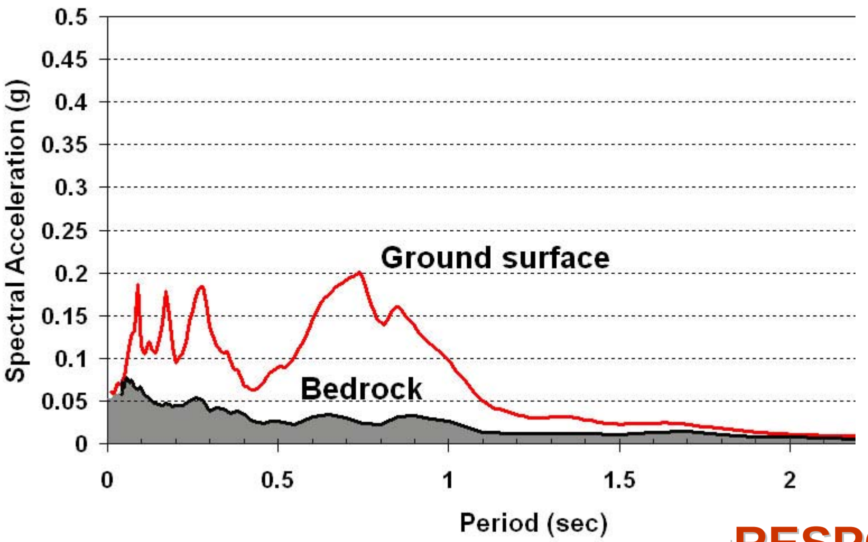




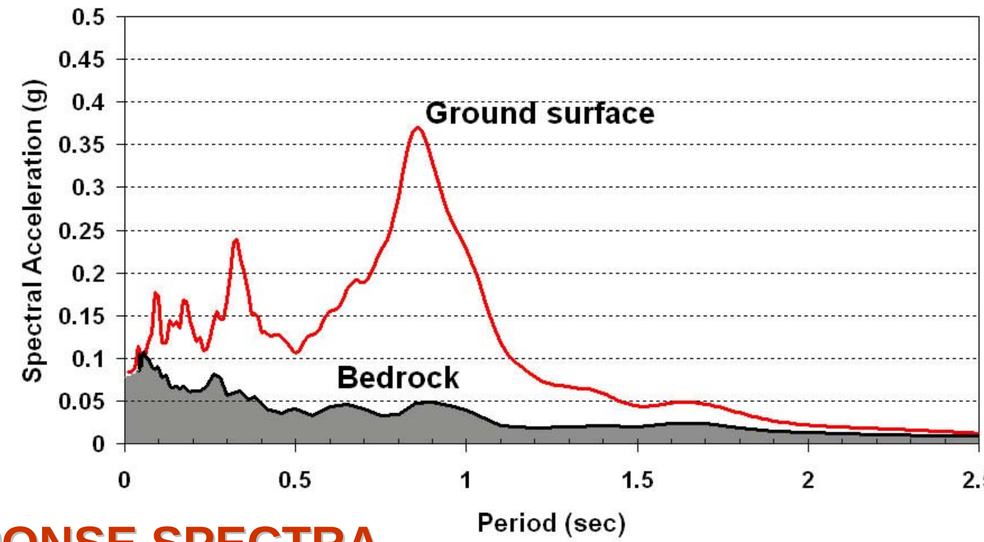
Magnitude 6.8 quake emanating from South Central Illinois at 110 km

RESPONSE SPECTRA

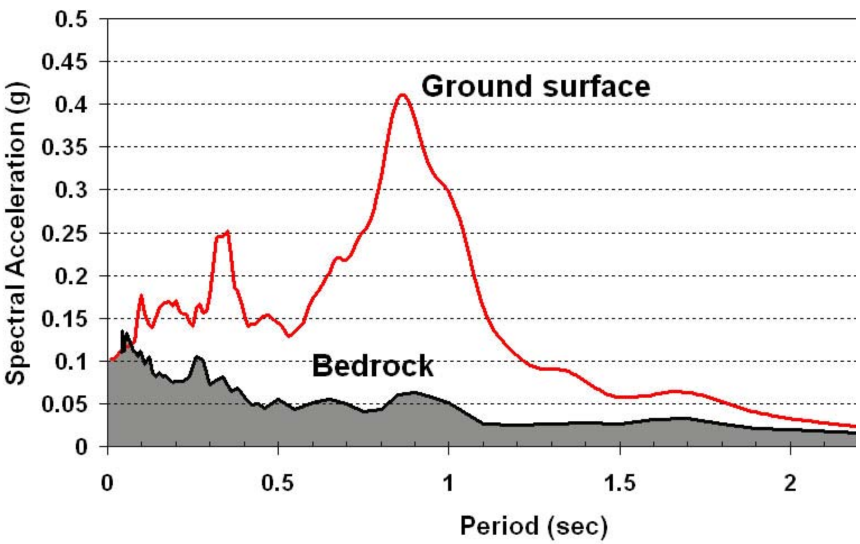
Rock and Ground surface spectral accelerations for Creve Coeur Bridge **M 6.0** event South Center Illinois at 110 km



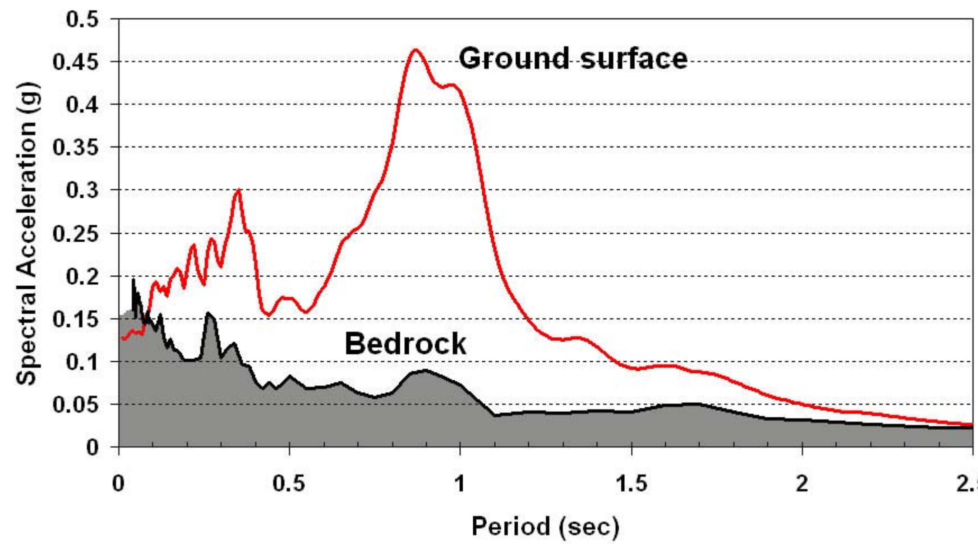
Rock and Ground surface spectral accelerations for Creve Coeur Bridge **M 6.3** event South Center Illinois at 110 km



Rock and Ground surface spectral accelerations for Creve Coeur Bridge **M 6.5** event South Central Illinois at 110 km



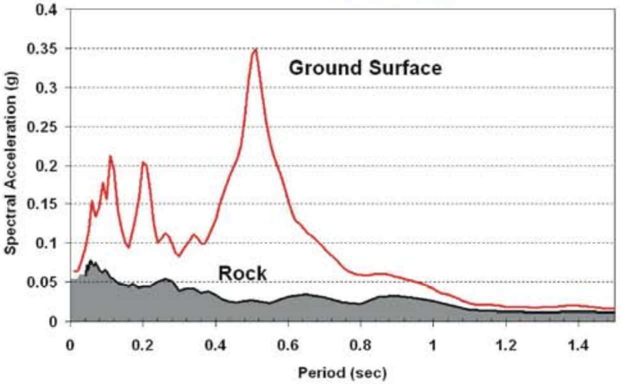
Rock and Ground surface spectral accelerations for Creve Coeur Bridge **M 6.8** event South Center Illinois at 110 km



Effect of Soil Thickness on RESPONSE SPECTRA

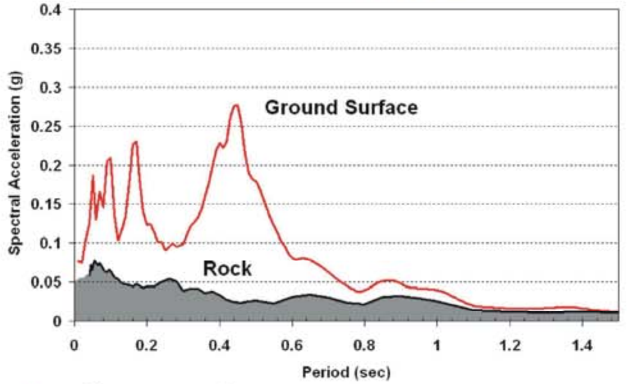
Soil Thickness: 25 m

Peak SA = 0.35 g
Peak Period = 0.51 sec



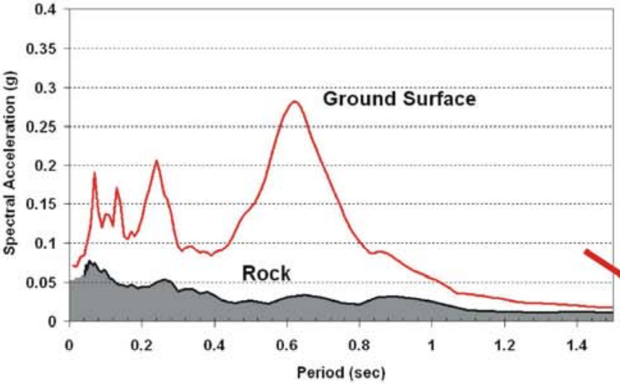
Soil Thickness: 22 m

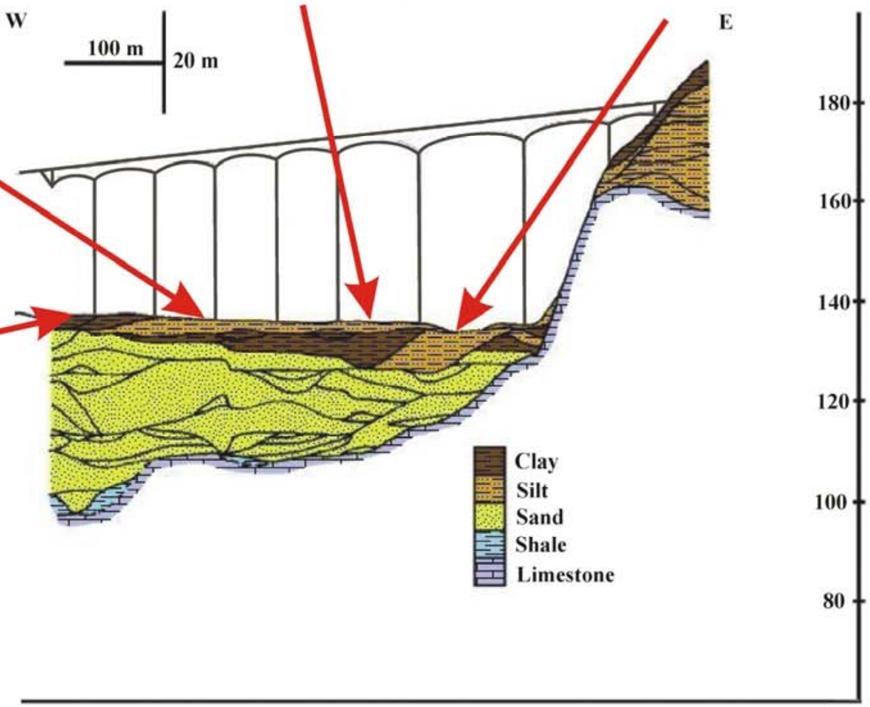
Peak SA = 0.28 g
Peak Period = 0.45 sec

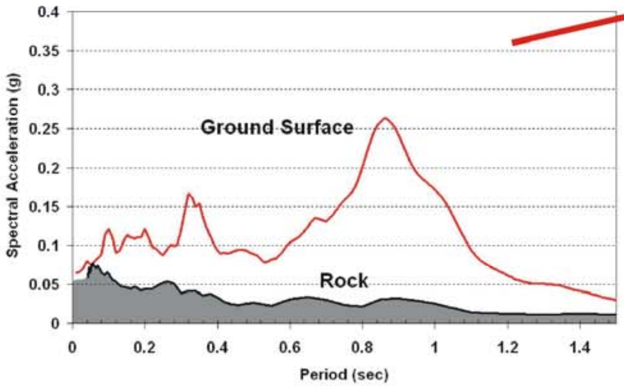


Soil Thickness: 28 m

Peak SA = 0.28 g
Peak Period = 0.62 sec

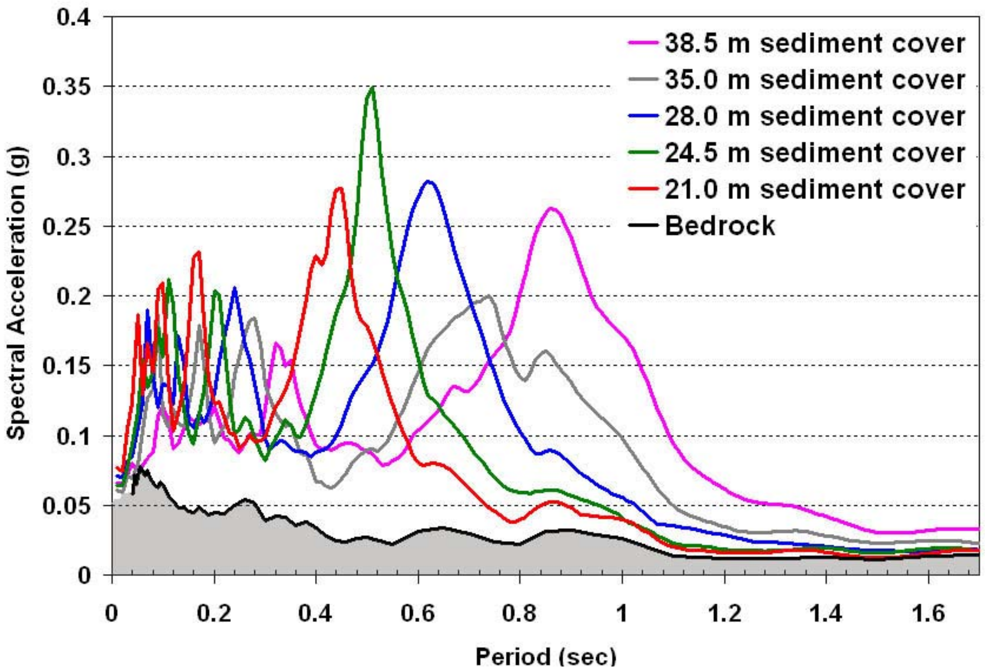






Soil Thickness: 39 m

Peak SA = 0.26 g
Peak Period = 0.87 sec

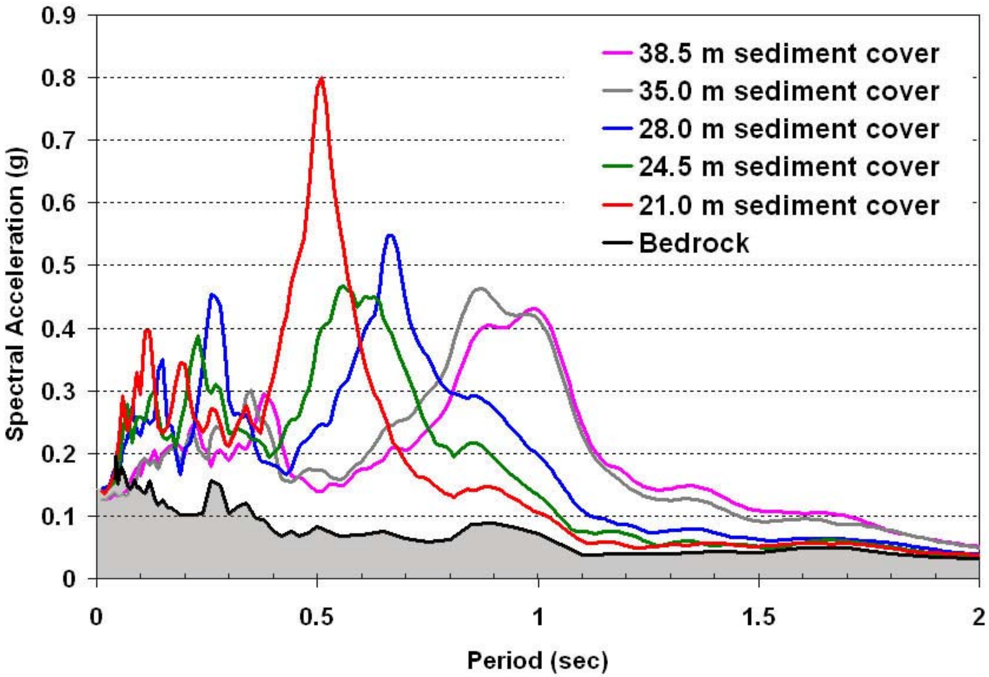


Magnitude 6.0 event at a distance of 110 km

The spectral acceleration is highest when the soil thickness is close to 25 m for M 6.0 quake at 110 km.

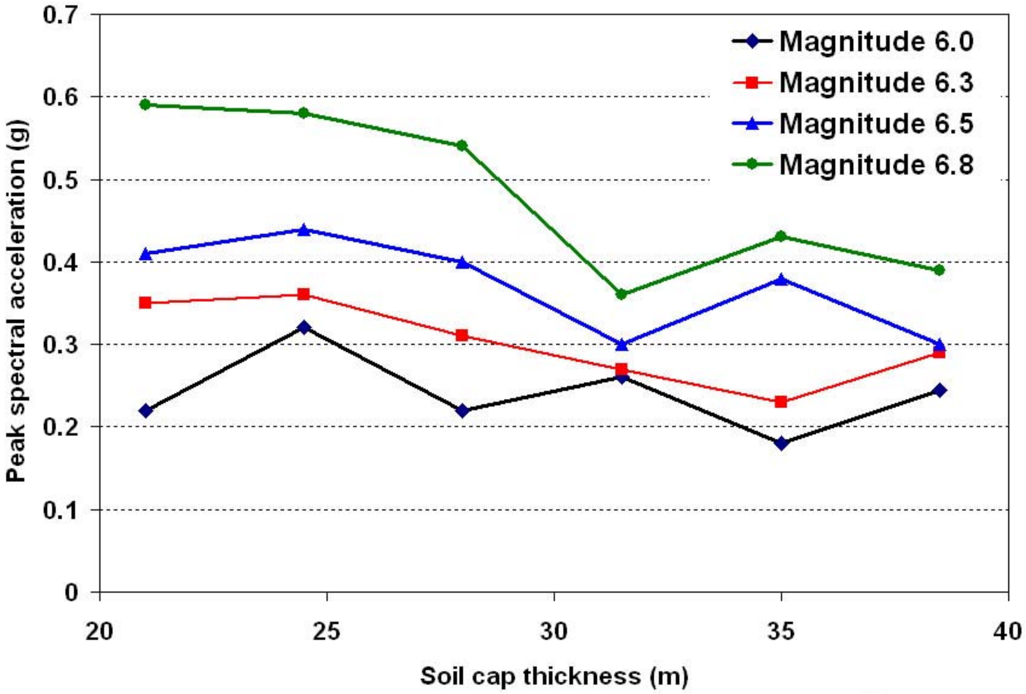
But, the spectral acceleration increases when the soil thickness drops to 21 m for a M 6.8 quake at the same distance.

From these figures it can be appreciated that the soil thickness may have a significant effect on both the peak accelerations and periods.



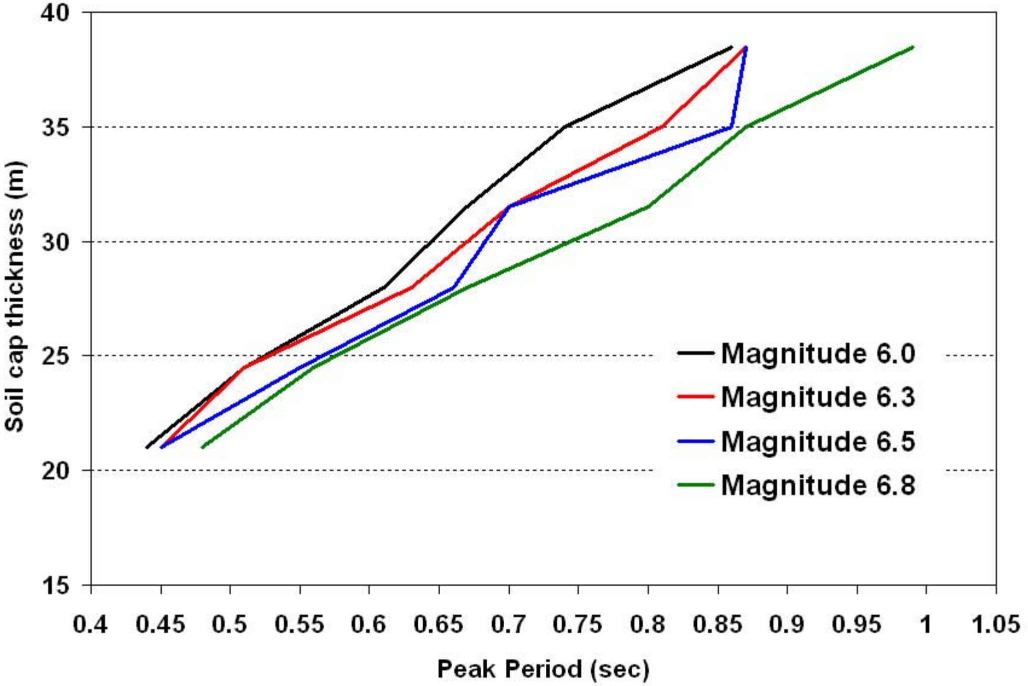
Magnitude 6.8 event at a distance of 110 km

Seismic site response varies markedly with the thickness of late Quaternary cover



Effect of sediment cover thickness on the <u>peak spectral accelerations</u> for Creve Coeur Bridge Site for M 6.0 to 6.8 events at 210 km

Effect of sediment cover thickness on the <u>peak period</u> for Creve Coeur Bridge Site for M 6.0 to 6.8 events at 210 km



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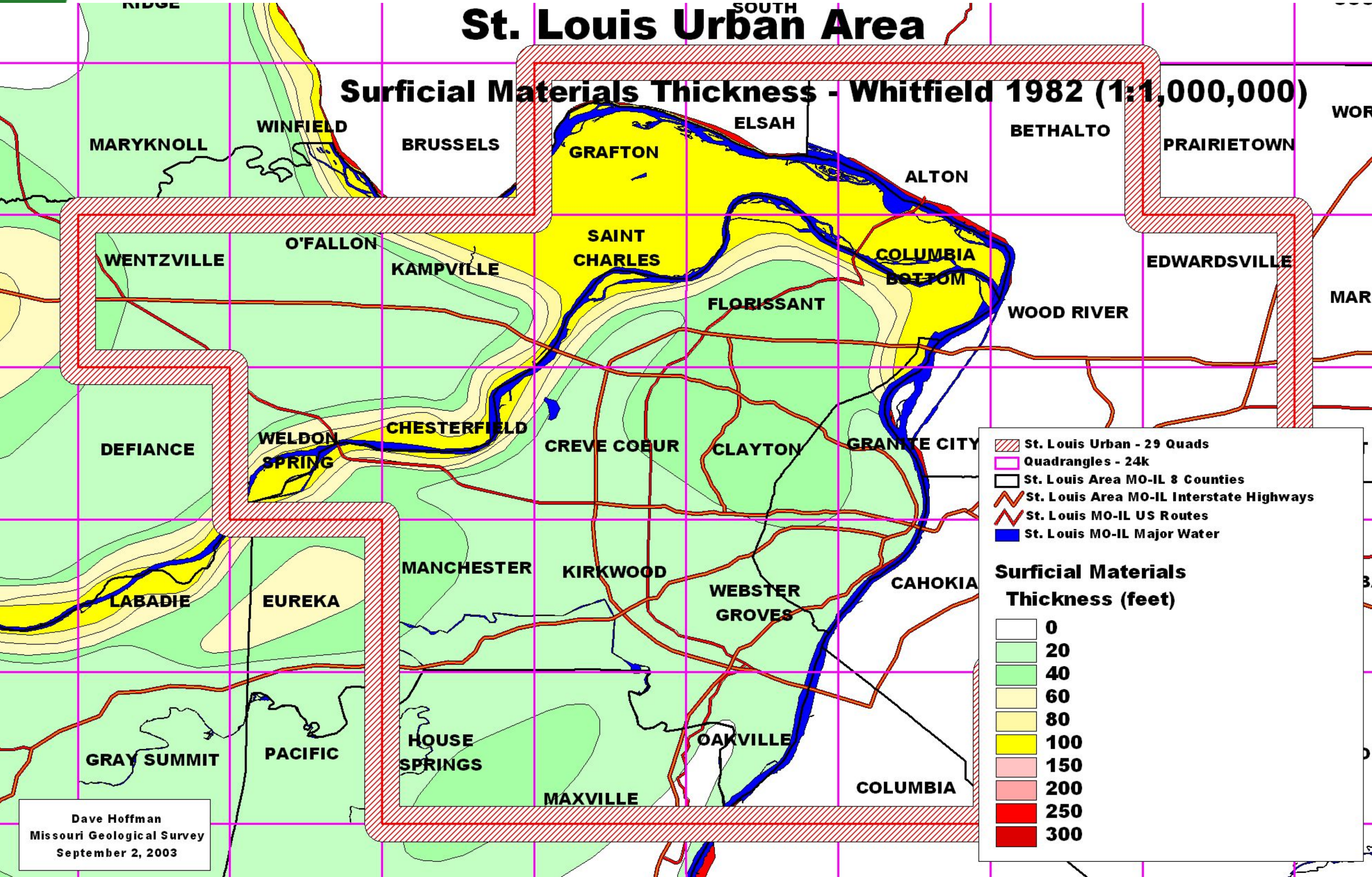
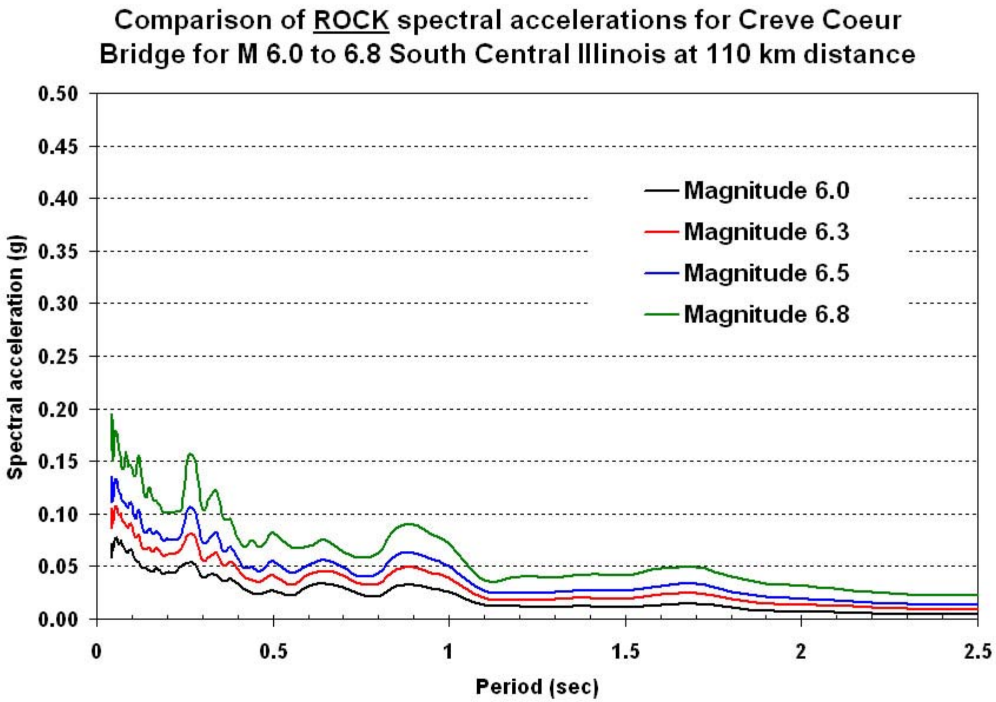
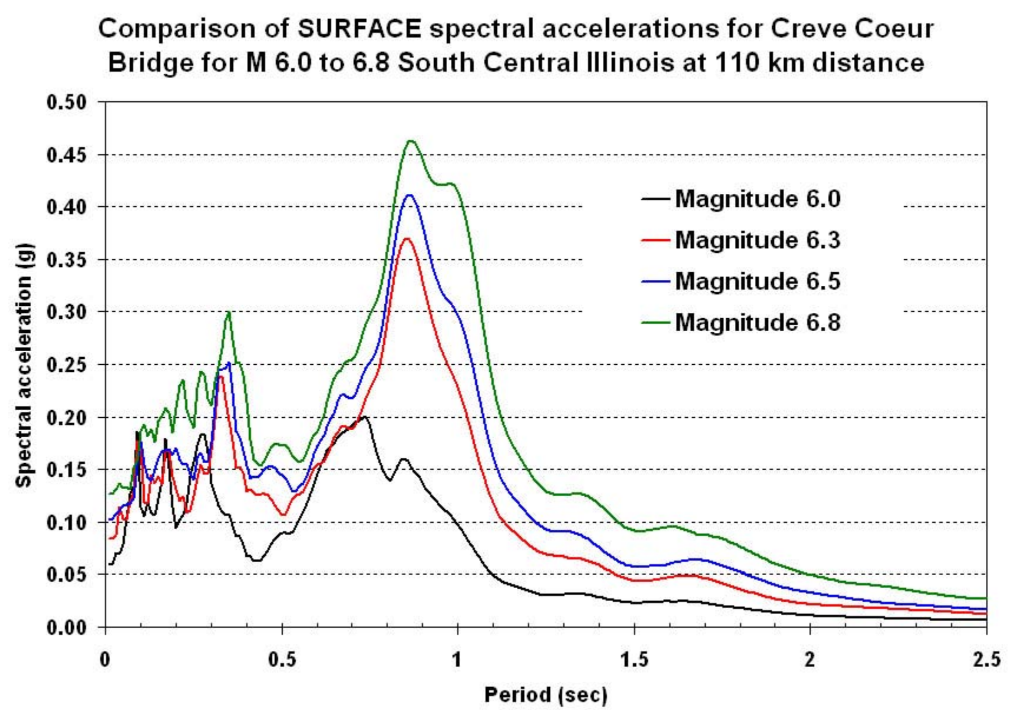
St. Louis Area Surficial Geology Thickness





Rock Spectral Accelerations increase as magnitude increases

Ground Surface spectral accelerations increase as magnitude increases



Site amplification is the ratio of the response spectra of a soil site to the response spectra of the underlying bedrock.

What Causes Amplification of Ground Motion?

- **Resonance** within the soil column overlying much stiffer basement rocks
- **Impedance Ratio** between the rigid basement rock and the unconsolidated soils lying over them
- **Conservation of energy** of the incoming seismic wave train (e.g. wave energy arriving at a much higher rate than can be propagated through the soft soil cover)

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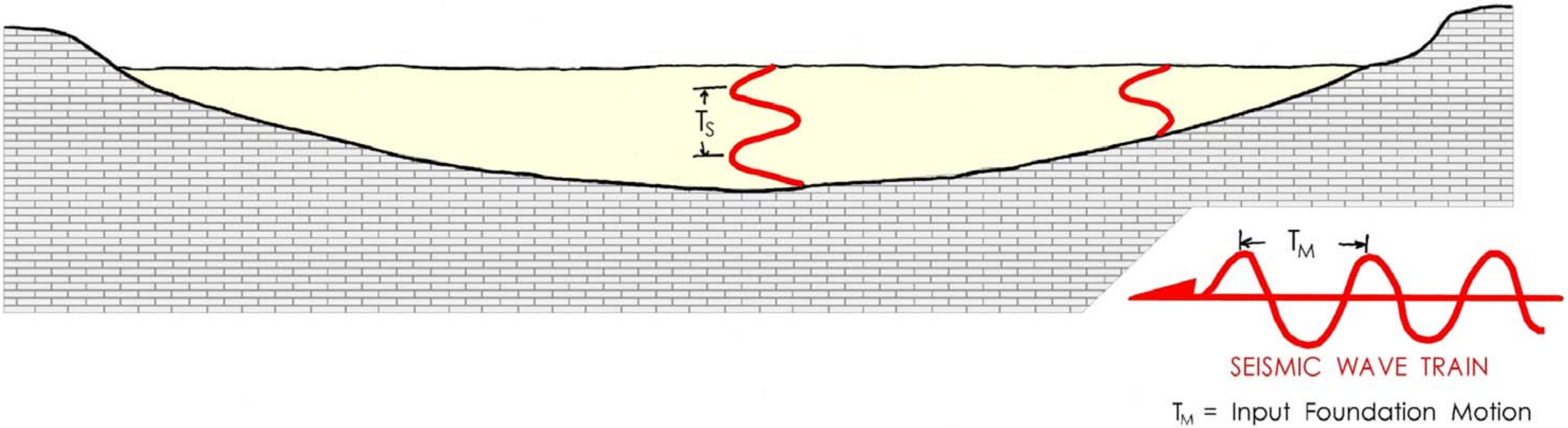
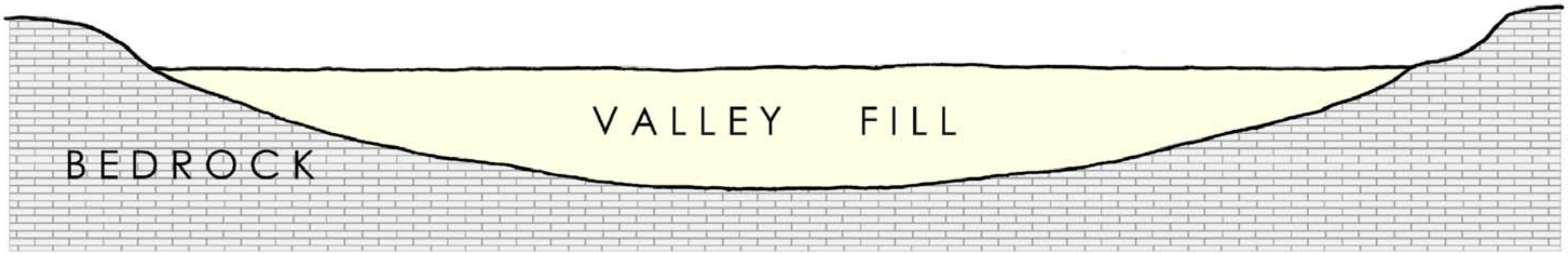
FUNDAMENTAL PERIOD of SAND-FILLED BEDROCK CHANNEL

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

IMPEDANCE



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

- **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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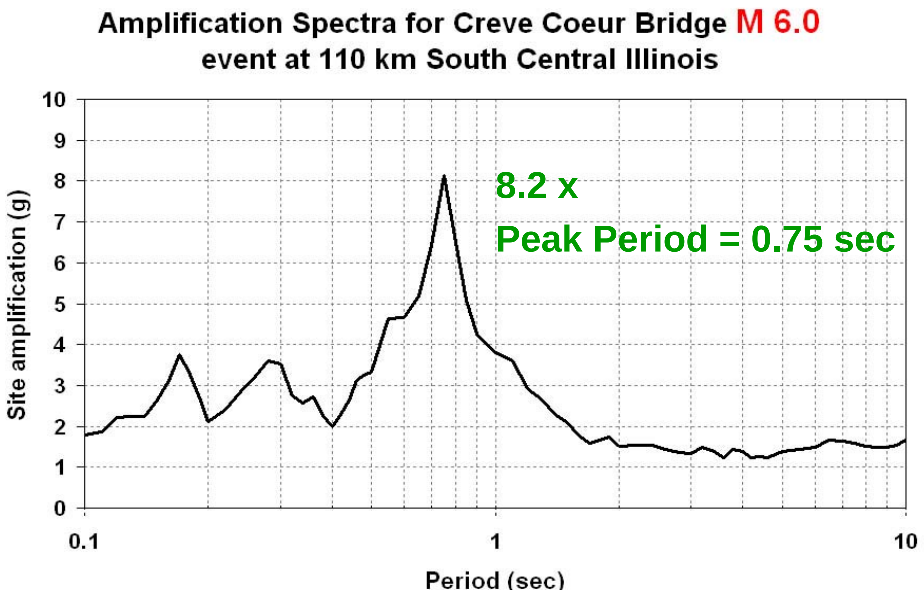
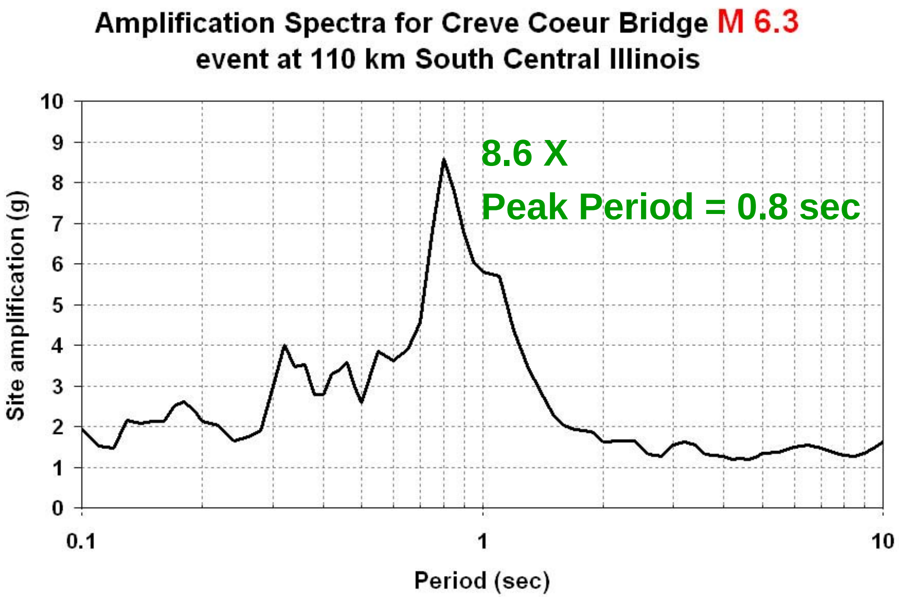
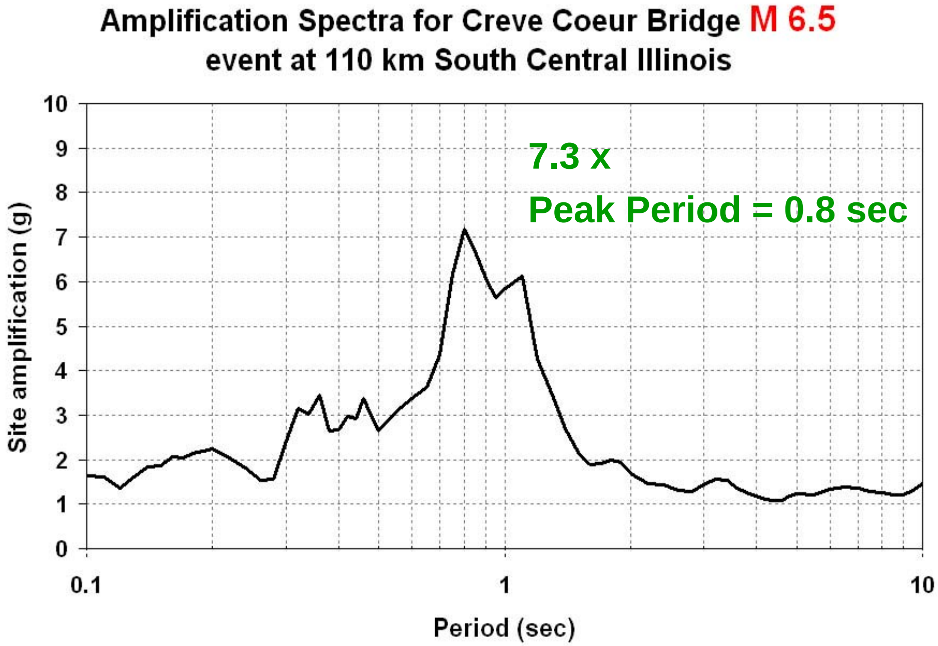
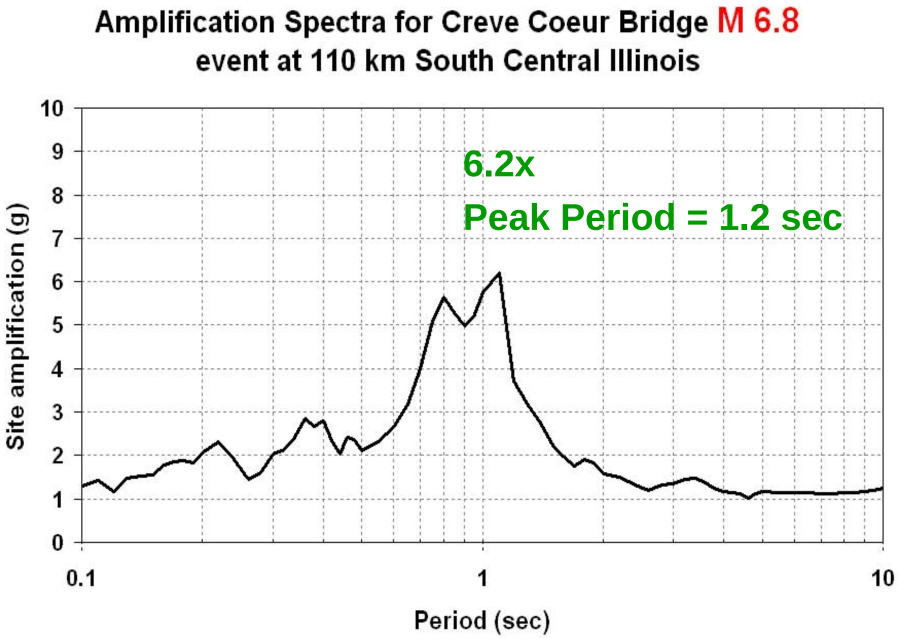
AMPLIFICATION at 110 km distance









EFFECT OF MAGNITUDE ON AMPLIFICATION

- The amplification of seismic energy through soil cover is greater in lower magnitude earthquakes because the weaker ground motions are of insufficient amplitude to trigger an inelastic response (nonlinear soil effect), which causes substantive damping of incoming seismic energy.
- This phenomenon results in greater percent amplification of incoming seismic energy for smaller magnitude events.

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

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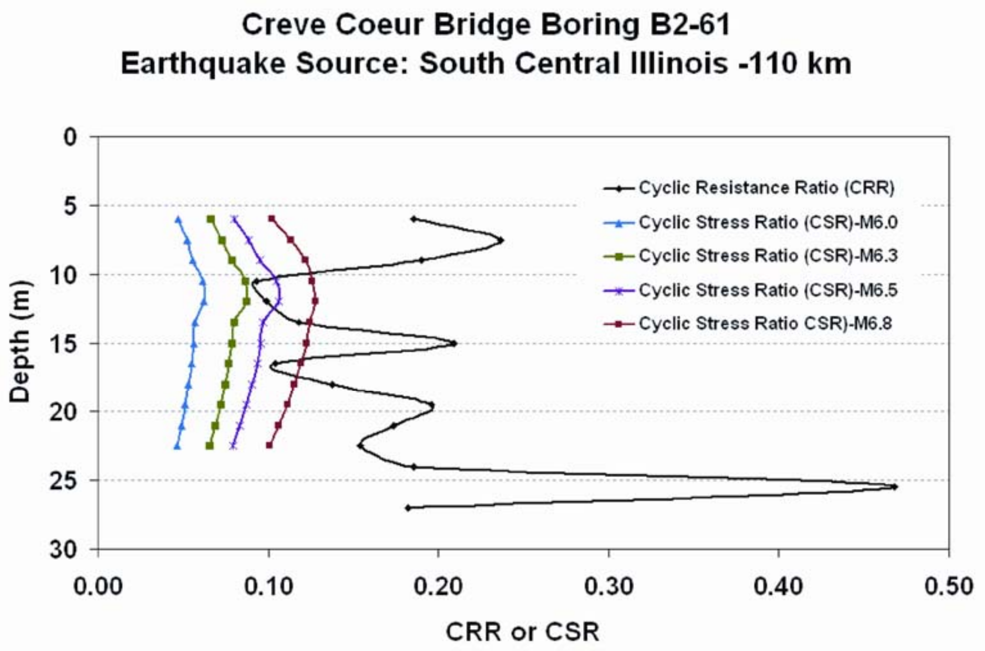
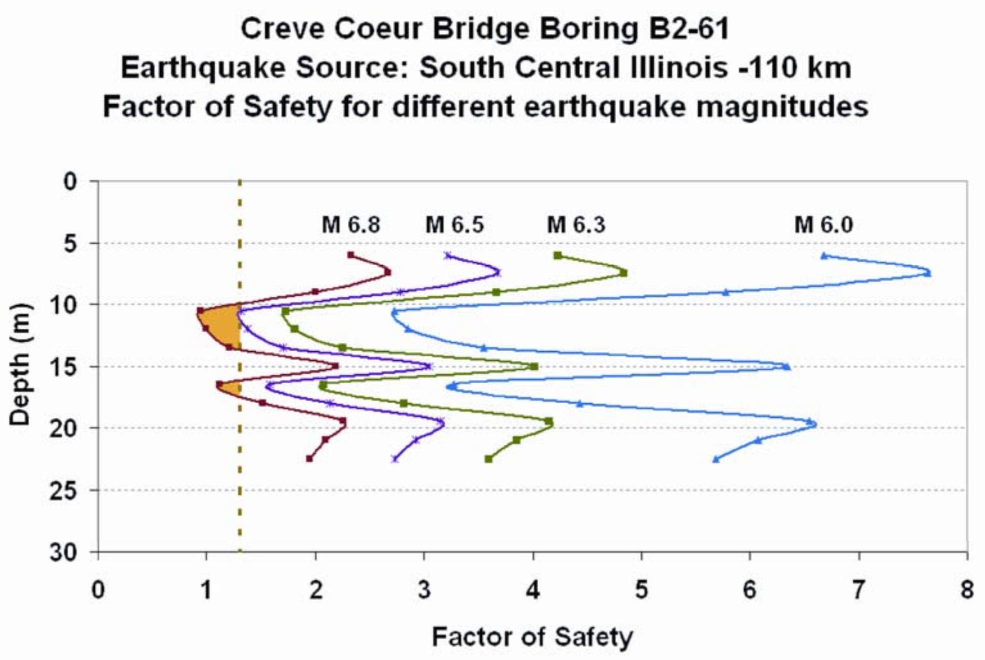
LIQUEFACTION or "QUICK SAND" CONDITION

Liquefaction is a failure mechanism by which cohesionless materials (sand and silt) lose shear strength when the pore pressure equals the effective confining stress. It is usually limited to the upper 50 feet and typically occurs in silt, sand and fine gravel.

St Louis Area Liquefaction Screening Analysis





Liquefaction is predicted in the Missouri River Flood Plain for an earthquake magnitude 6.8 event from South Central Illinois and Wabash Valley Seismic Zones.

Liquefaction to depths of 18 m predicted for quake Magnitudes > 6.5

Thank You

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