

General Geologic Setting and Seismicity of the FHWA Project Site in the New Madrid Seismic Zone

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Geology and Seismicity - 1



General Geologic Setting and Seismicity of the FHWA Project Site in the New Madrid Seismic Zone

- Central and Eastern United States Earthquake Hazard
- Regional geology, topography and seismicity
- Mississippi Embayment and Reelfoot Rift (Mississippi Valley Graben)
- Stratigraphy
- Geologic structure, faults and seismicity
- Sandblows
- Attenuation
- Local site alluvial soils
- Important Considerations



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Central and Eastern United States Earthquake Hazard

Hazard Map

- Based on geology and seismology
- Probabilistic map

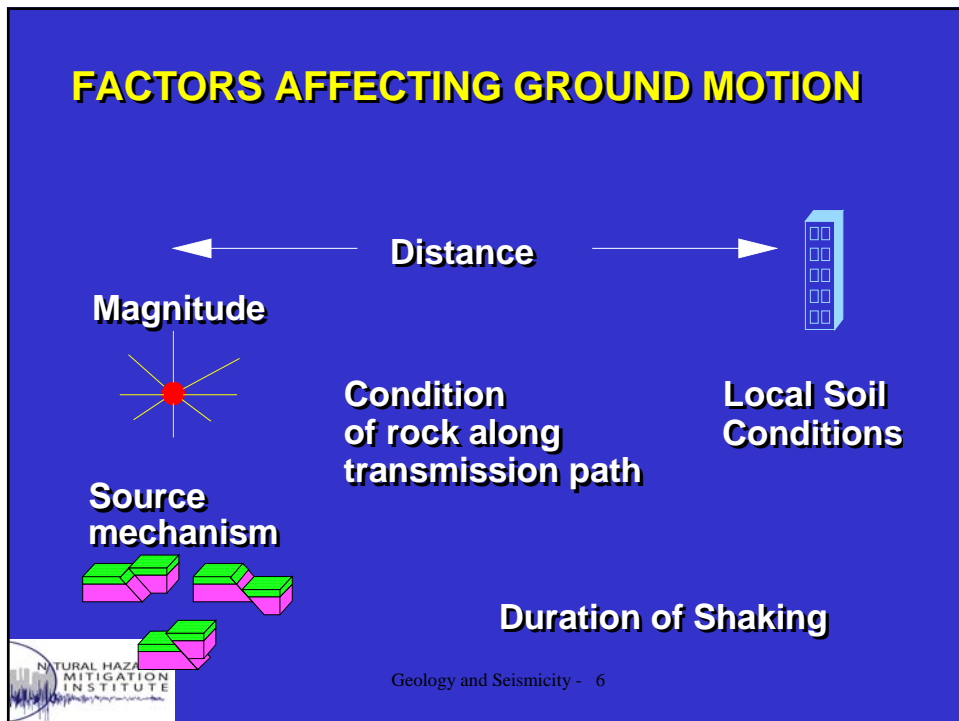
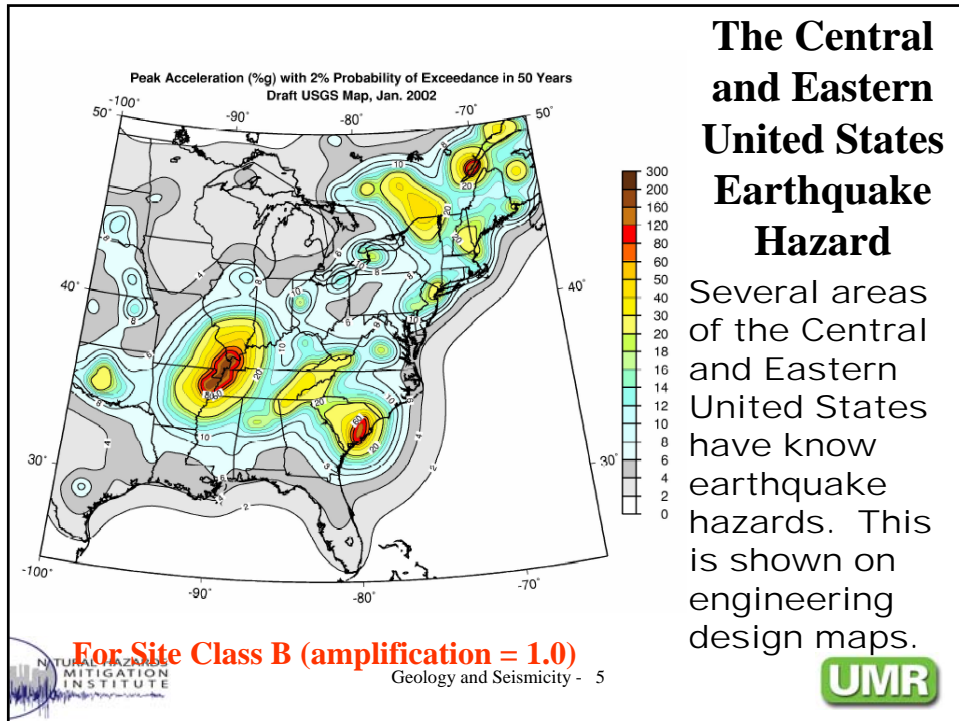
Geologic Factors Affecting Ground Motion

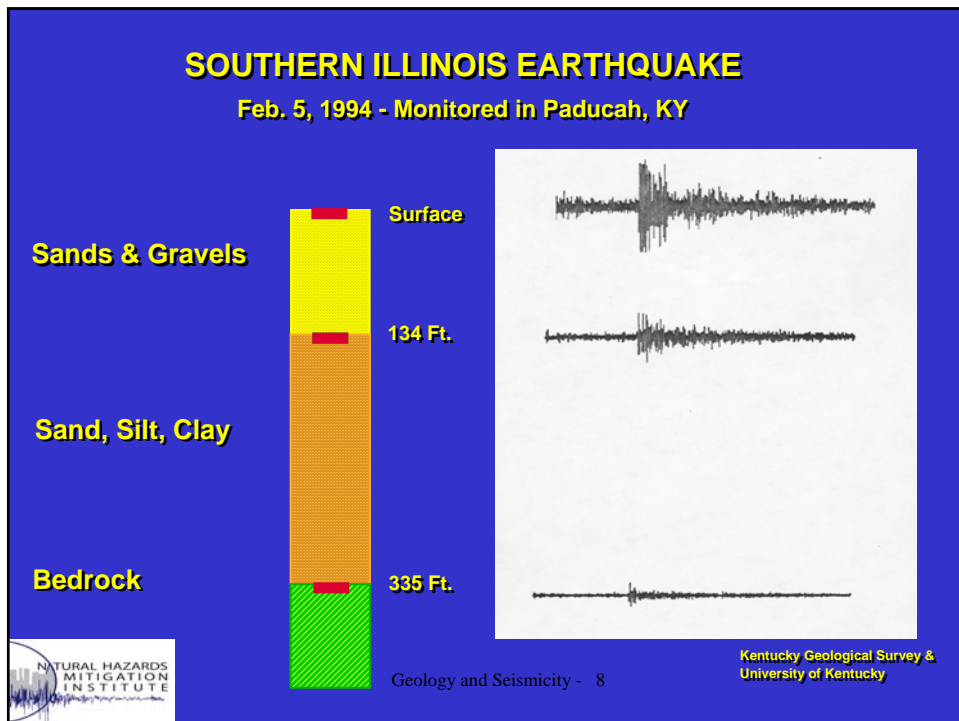
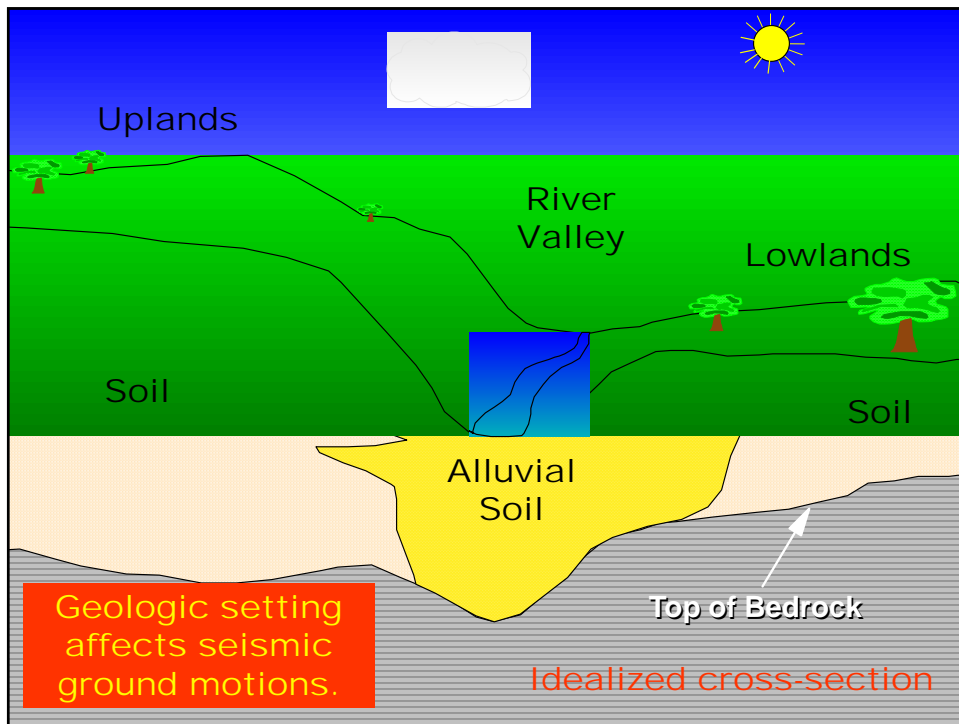
- Earthquake magnitude
- Source mechanism
- Distance
- Condition of rock along transmission path
- Local site conditions
- Duration of shaking

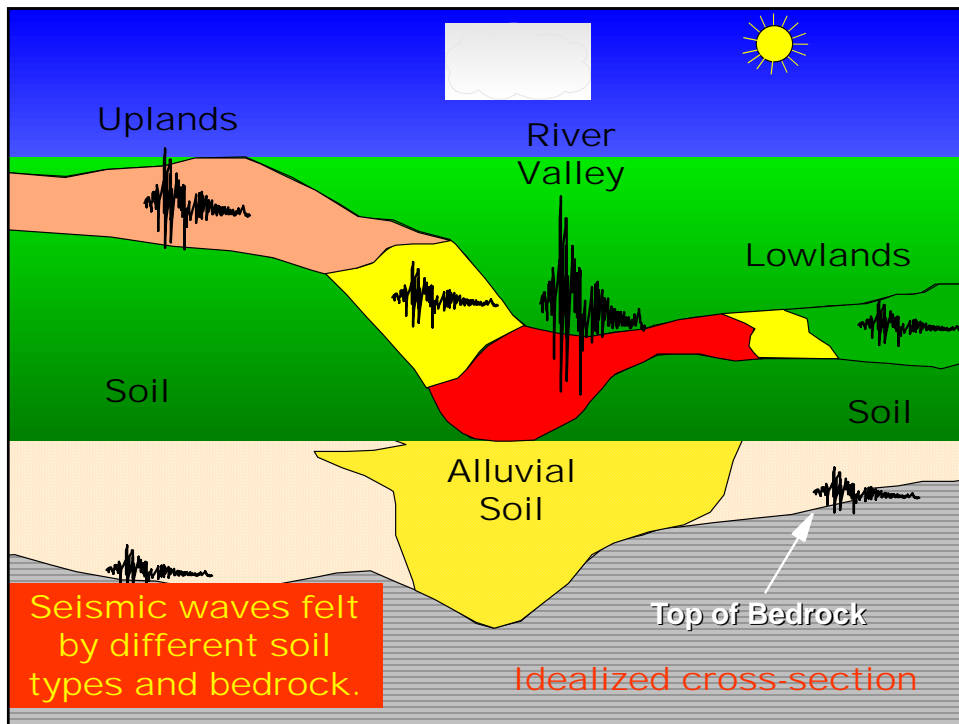


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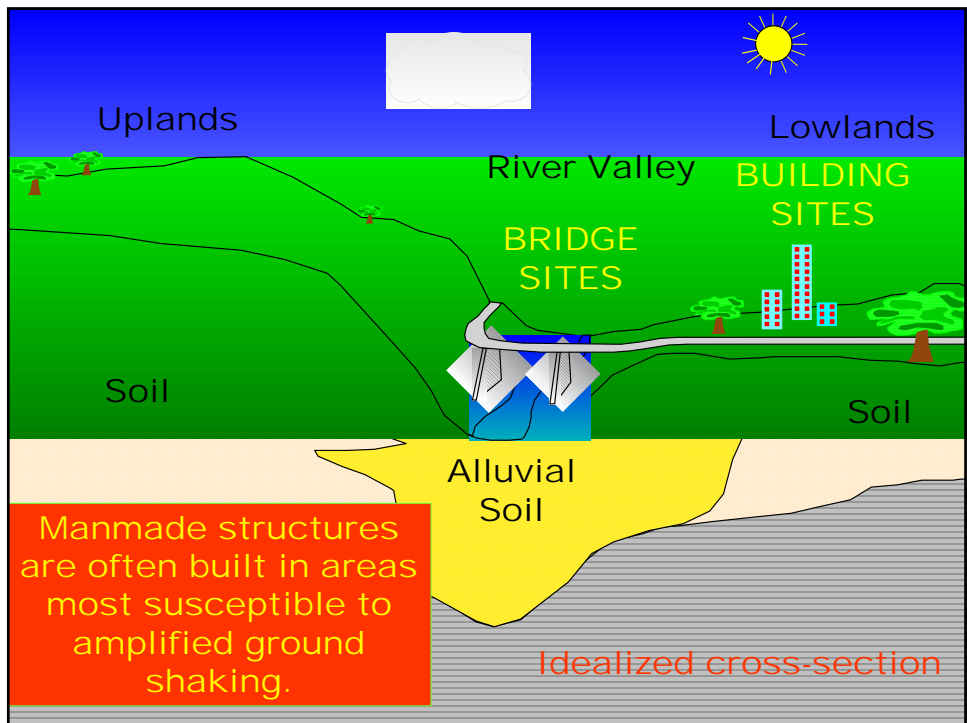
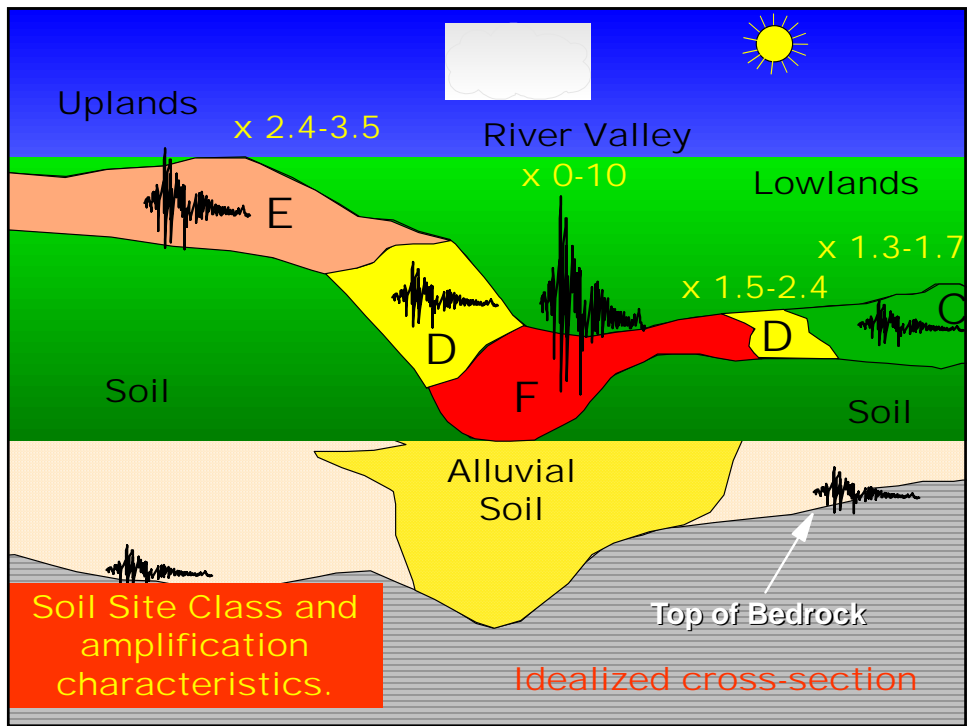


Soil Type and Properties Affect Site Amplification

Increasing Amplification ↓

Soil Profile Type	Average Shear Wave Velocity (Ft/Sec)	Possible Amount of Amplification times bedrock Ground Motions
A	>5,000	0.8
B	2,500 - 5,000	1.0
C	1,200 - 2,500	1.3 - 1.7
D	600 - 1,200	1.5 - 2.4
E	<600	2.4 - 3.5
F	Not Applicable	Site Specific Investigation should be performed - can be <1 to as high as 10X

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Regional geology, topography and seismicity

Geology

- Stable continental interior
 - Older rocks
 - Glacial sediments
- Gulf Coastal Plain
- Mississippi Embayment
 - New Madrid Seismic Zone

Topography

- Very flat

Seismicity

- Northern Mississippi Embayment



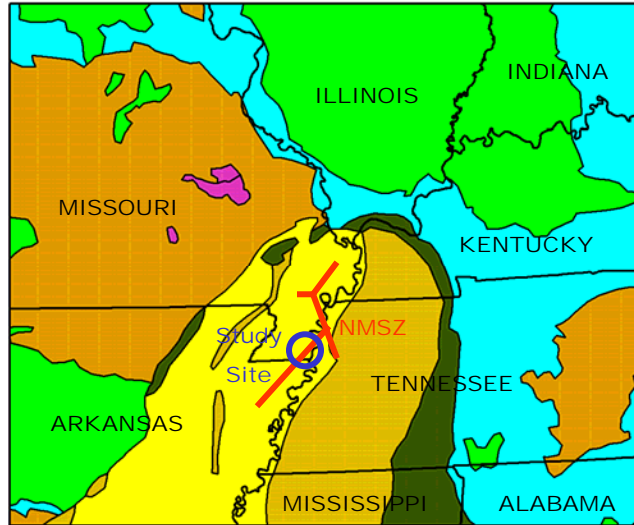
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General Geology of the New Madrid Seismic Zone and Mississippi Embayment Area

- Mississippi Embayment
- Soft Sediments
 - Quaternary alluvium
 - Tertiary
 - Cretaceous
- Older Bedrock
- Mississippian
 - Pennsylvanian
 - Ordovician
 - Precambrian

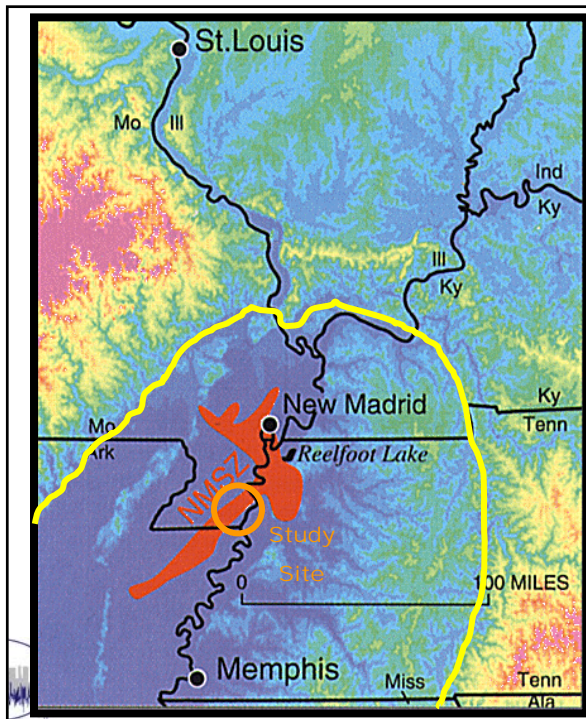
The geology and related seismicity create the earthquake hazard.



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Ground Elevation and Topographic Relief In the Central United States Area



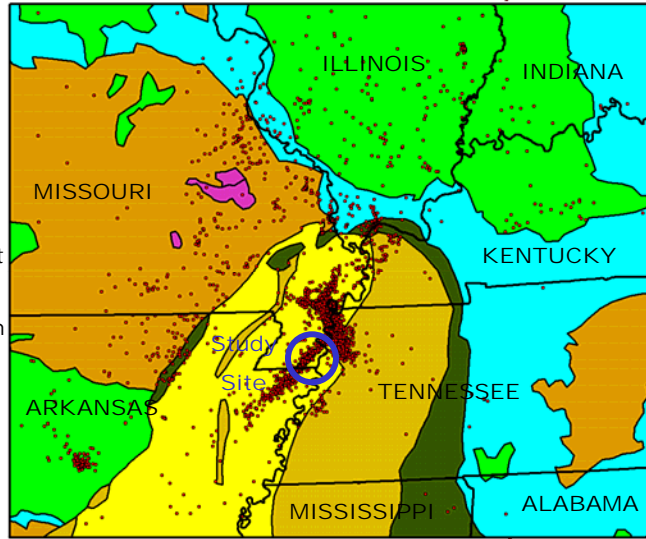
The New Madrid Seismic Zone (red) is in the flat lowlands (purple) of the Mississippi Embayment (yellow line). The Mississippi Embayment is a depressed area due to a weakness in the North American tectonic plate crust.

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Central United States Seismicity & General Geology

Seismicity is associated with the Mississippi Embayment crustal weakness.

Mississippi Embayment
 Soft Sediments
 Quaternary alluvium
 Tertiary
 Cretaceous
 Older Bedrock
 Mississippian
 Pennsylvanian
 Ordovician
 Precambrian



● Earthquake Epicenters Since 1994

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General Geologic Setting and Seismicity of the FHWA Project Site in the New Madrid Seismic Zone

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Mississippi Embayment and Reelfoot Rift (Mississippi Valley Graben)

Mississippi Embayment

- Basin with thick soft young sediments
- Hard bedrock very deep
- Flat lowlands and flat to gently rolling uplands

Reelfoot Rift (Mississippi Valley Graben)

- Old weakness in Earth crust
- Identified by geophysical methods
 - Magnetic signature
 - Gravity signature
- Location of seismicity

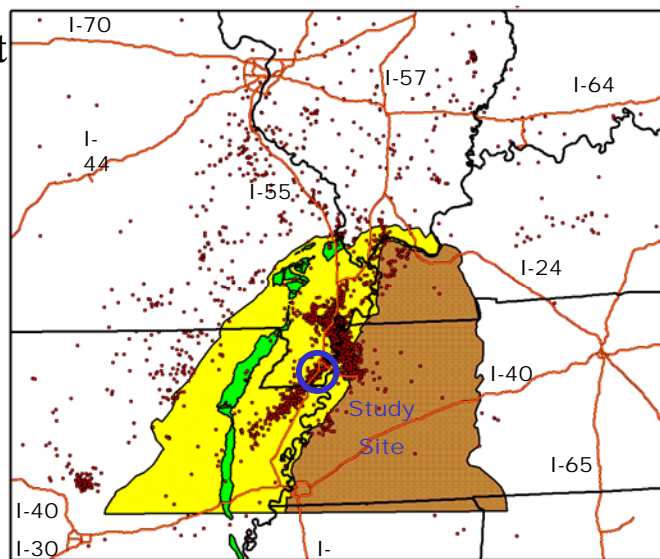


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Mississippi Embayment & Central United States Seismicity

- Lowlands: Alluvium
- Uplands: Crowley's Ridge
- Uplands: Kentucky & Tennessee

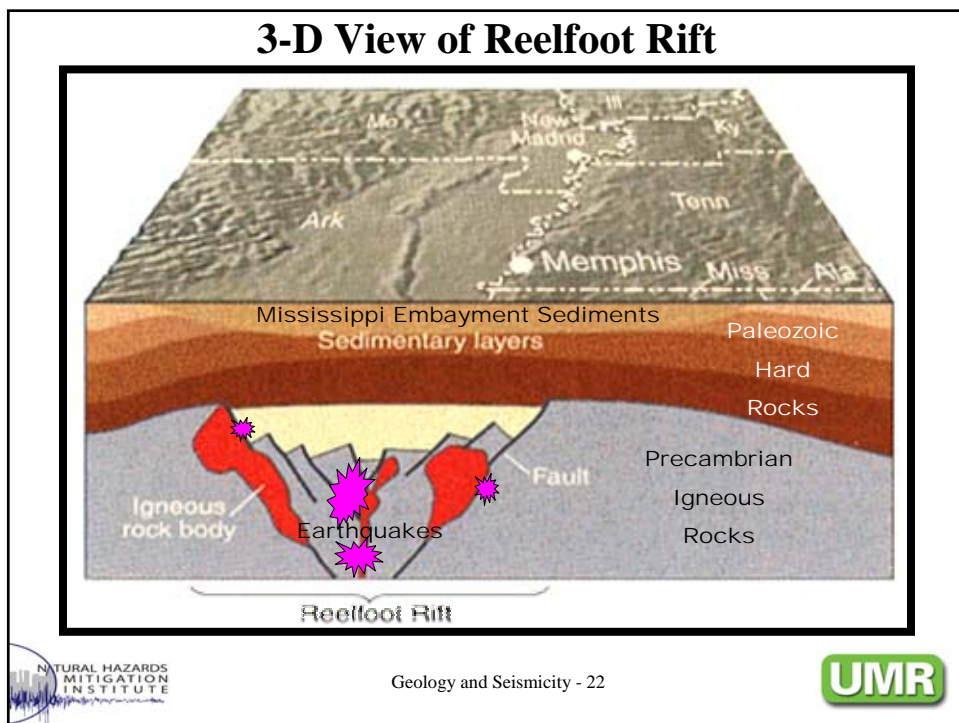
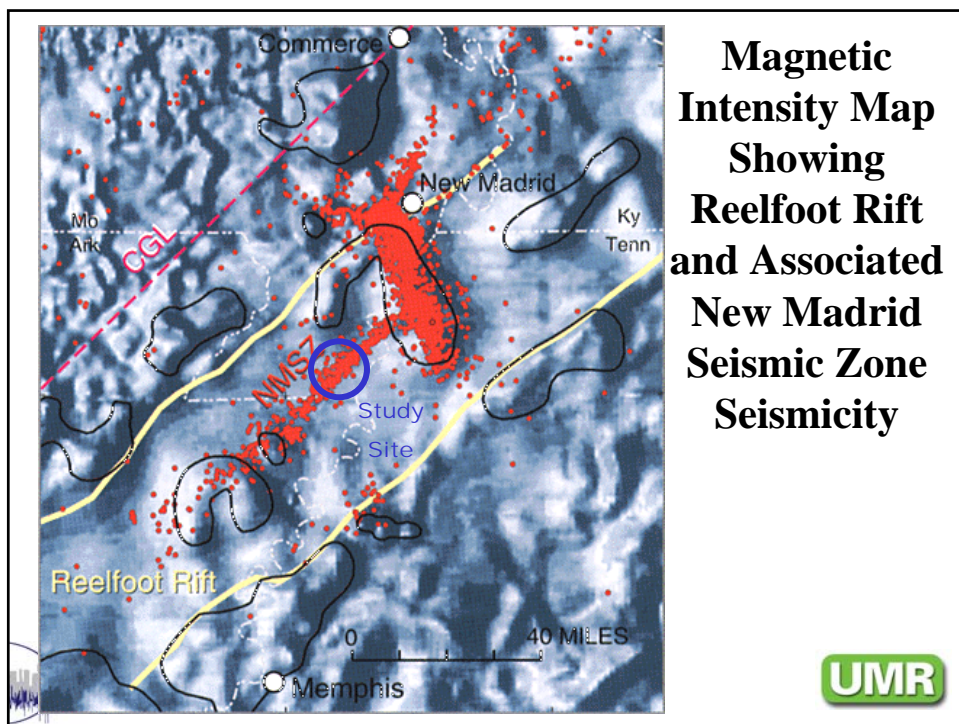


● Earthquake Epicenters Since 1994
— Interstate Highways



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Stratigraphy

Stratigraphic Column

- Alluvium
- Tertiary and Cretaceous unconsolidated sediments
- Bedrock

Structural Contour Maps

- Limited deep data
- Contours for various strata
- Profile
- Newer data sources



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Generalized Stratigraphy of the Northern Mississippi Embayment



SOURCES
Hosman and Weiss, 1991
Crone, 1981
Grohskopf, 1955

ERA	PERIOD	SYSTEM	SUBSYSTEM	FORMATION	THICKNESS (feet)	LITHOLOGIC CHARACTER	AGE (Ma)	LOCATION
PHANEROZOIC	QUATERNARY	Alluvium	Alluvium	Alluvium	0-100	Sand and gravel, some clay, lignite.	0.001	W, N, S, E
				Loess	0-10	Silt, yellow-brown.	0.001-0.01	W, N, S, E
				Lafayette	0-10	Gravel, sand, clay.	0.001-0.01	W, N, S, E
				Holly Springs ?	1300	Sand, several well-developed clay zones, thick basal sand.	0.001-0.01	W, N, S, E
				Ackerman ?	650	Clay, blue-gray, conchoidal fracture, siderite and silt in upper portion. Glauconitic and calcareous in lower portion.	0.001-0.01	W, N, S, E
	TERTIARY	Midway Group	Midway Group	Porters Creek	650	Clay, blue-gray, conchoidal fracture, siderite and silt in upper portion. Glauconitic and calcareous in lower portion.	0.001-0.01	W, N, S, E
				Clayton	15	Limestone and calcareous clay, fossiliferous, glauconitic.	0.001-0.01	W, N, S, E
				Owl Creek	70	Clay, brown, sandy, glauconitic. Very fossiliferous.	0.001-0.01	W, N, S, E
				Mc Nairy (Ripley)	250	Sand, sandy clay, glauconitic, fossiliferous.	0.001-0.01	W, N, S, E
				Ozan ?	250	Sand, calcareous sand and clay.	0.001-0.01	W, N, S, E
	MESOZOIC	CRETACEOUS	Lark	Marlbrook-Saratoga ?	250	Sand, calcareous sand and clay.	0.001-0.01	W, N, S, E
				Ballou	50	Limestone, very cherty.	0.001-0.01	W, N, S, E
				St. Louis	100	Limestone, very cherty.	0.001-0.01	W, N, S, E
				St. Louis	100	Limestone, very cherty.	0.001-0.01	W, N, S, E
				St. Louis	100	Limestone, very cherty.	0.001-0.01	W, N, S, E
PROTEROZOIC	PRECAMBRIAN	Precambrian	Precambrian	"Basement"	>50,000	Consolidated Rocks: various crystalline igneous or metamorphic rocks.	>50,000	W, N, S, E
				"Basement"	>50,000	Consolidated Rocks: various crystalline igneous or metamorphic rocks.	>50,000	W, N, S, E

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COLUMNAR SECTION

Southeastern Missouri Mississippi Embayment Area

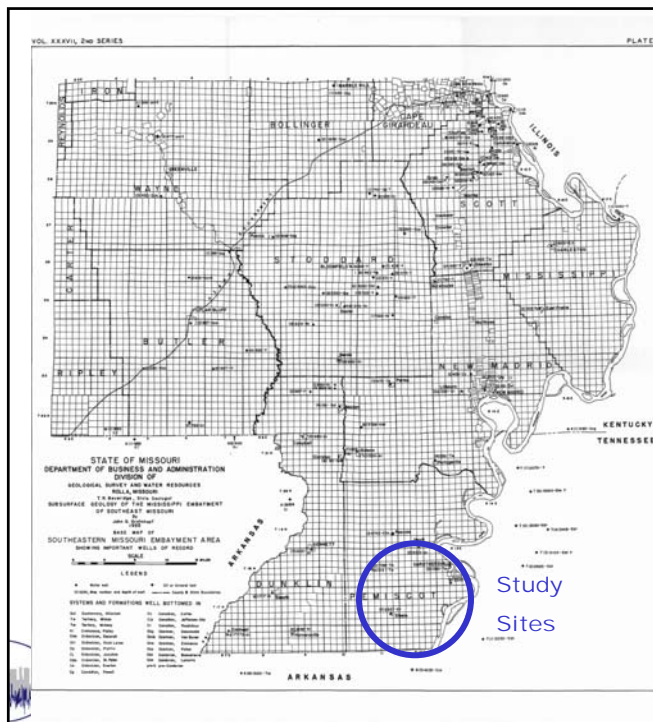
ERA	SYSTEM	FORMATION	MAXIMUM THICKNESS (in feet)	LITHOLOGIC CHARACTER
CENOZOIC	QUATERNARY	Alluvium	275	Sand and gravel, some clay, lignite.
		Loess	80	Silt, yellow-brown.
		Lafayette	60	Gravel, sand, clay.
	TERTIARY	Holly Springs ?	1300	Sand, several well-developed clay zones, thick basal sand.
		Ackerman ?		
		Porters Creek	650	Clay, blue-gray, conchoidal fracture, siderite and silt in upper portion. Glauconitic and calcareous in lower portion.
		Clayton	15	Limestone and calcareous clay, fossiliferous, glauconitic.
	CRETACEOUS	Owl Creek	70	Clay, brown, sandy, glauconitic. Very fossiliferous.
		Mc Nairy (Ripley)	250	Sand, sandy clay, glauconitic, fossiliferous.
		Ozan ?	250	Sand, calcareous sand and clay.
MESOZOIC	CRETACEOUS	Marlbrook-Saratoga ?	250	Sand, calcareous sand and clay.
		Ballou	50	Limestone, very cherty.

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Paleozoic and Older Rocks

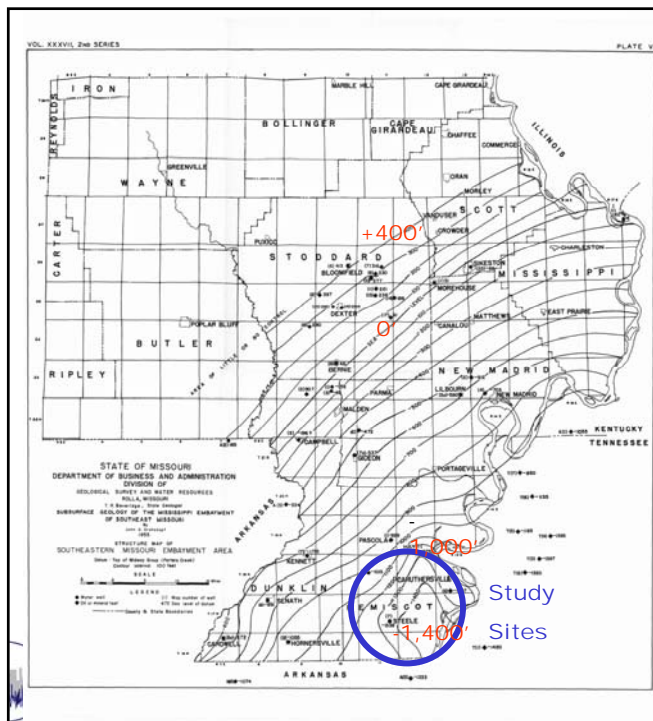
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**Southeast
Missouri
Mississippi
Embayment
Area Showing
Important
Deep Wells
(Grohskopf,
1955)**

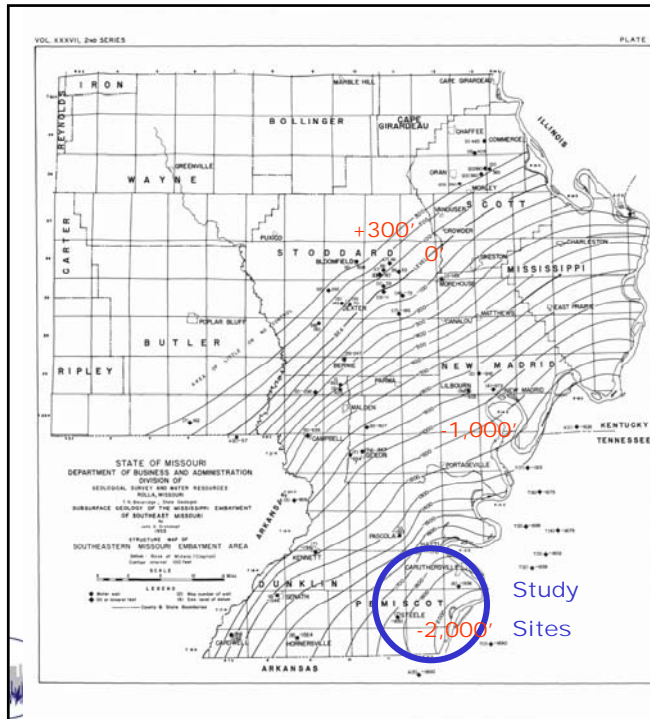
Study Sites



**Structural
Contours on
the Base of the
Wilcox Group
or Top of the
Midway
Group
(Grohskoph,
1955)**

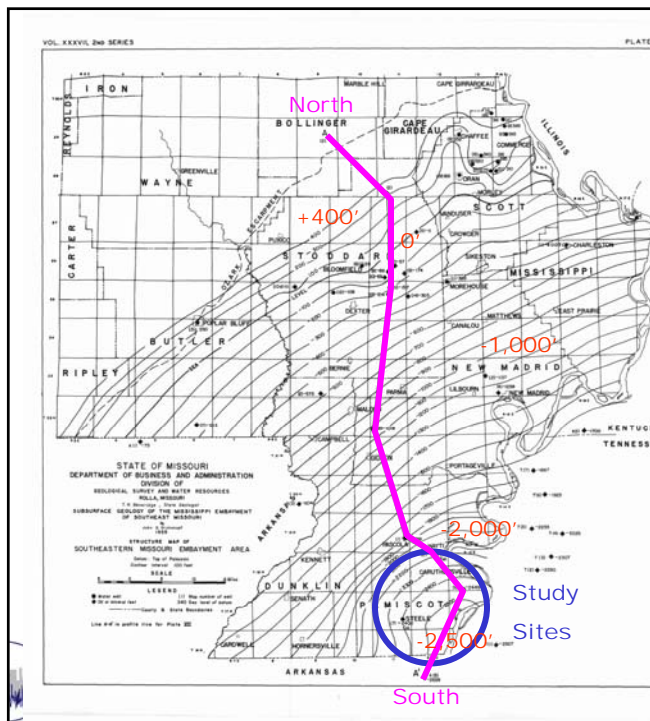
Study Sites





**Structural
Contours on
the Base of the
Midway
Group or Top
of the
Cretaceous
(Grohskopf,
1955)**

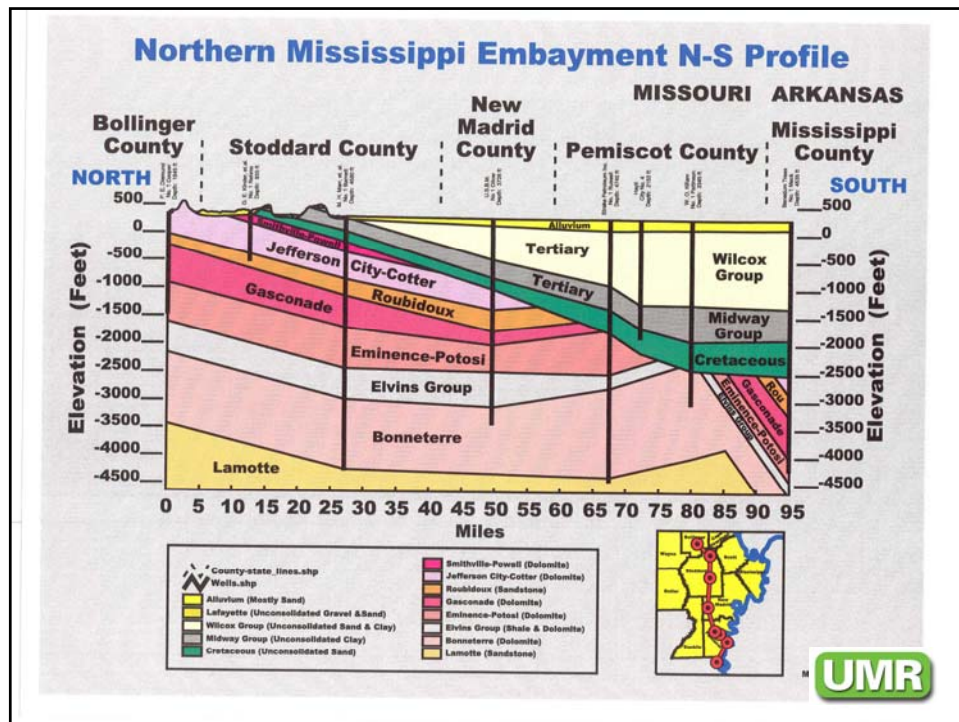
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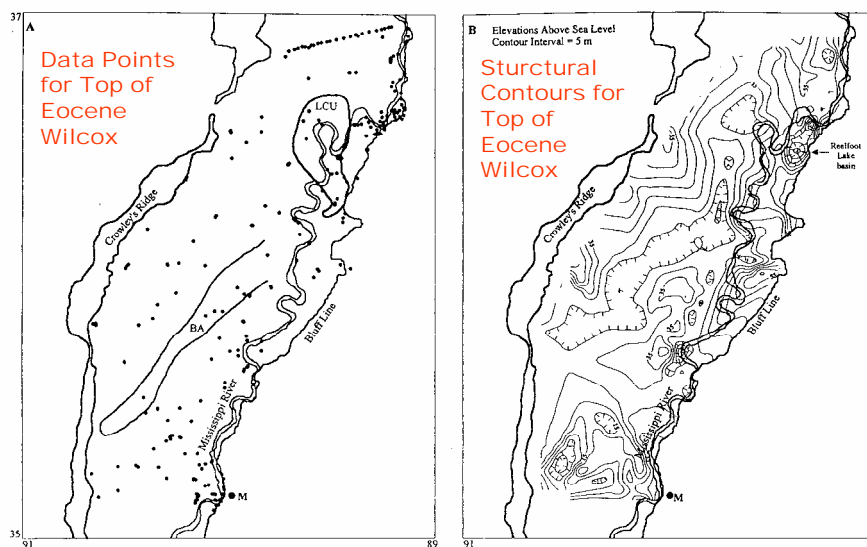
**Structural
Contours on
the Base of
the
Cretaceous or
Top of the
Paleozoic
(Grohskopf,
1955)**

— Profile Line

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More Detailed Stratigraphic Data for Select Areas



(Van Arsdale & TenBrink, 2000)

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Geologic structure, faults and seismicity

Buried Rift

- East northeast-west southwest compression

Seismicity Pattern

- Four faults
 - Three near vertical strike-slip faults
 - One low angle reverse thrust fault

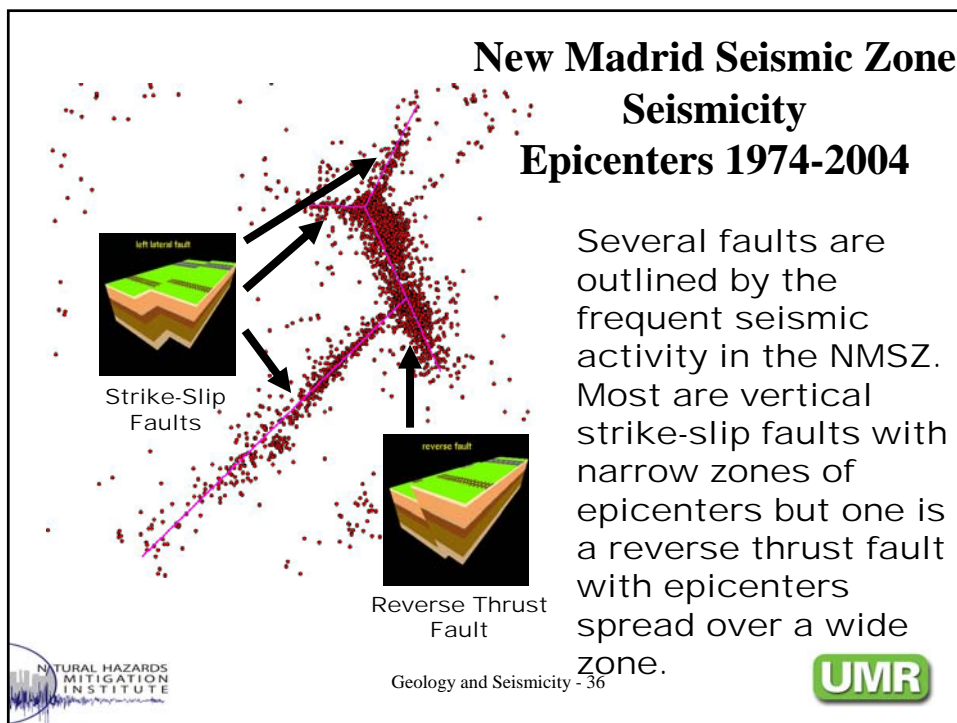
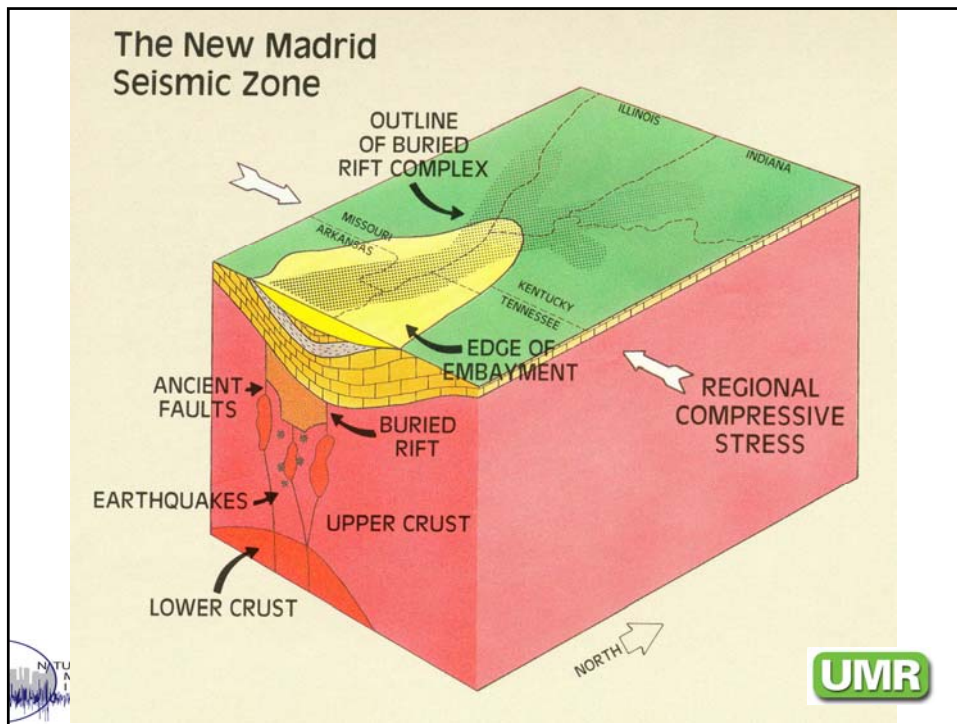
Bridge Sites

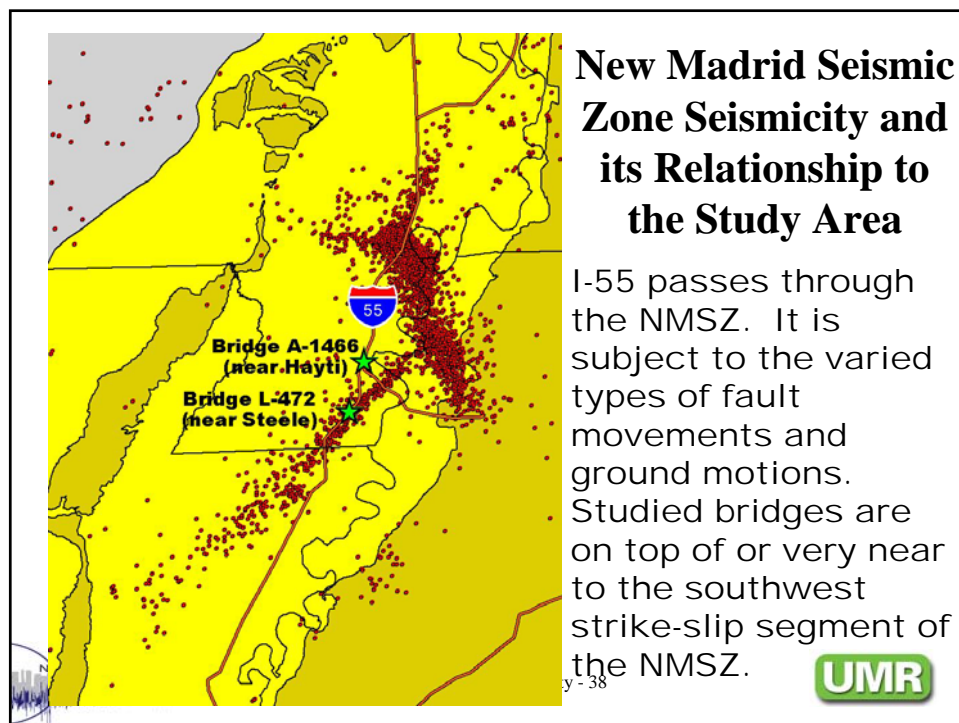
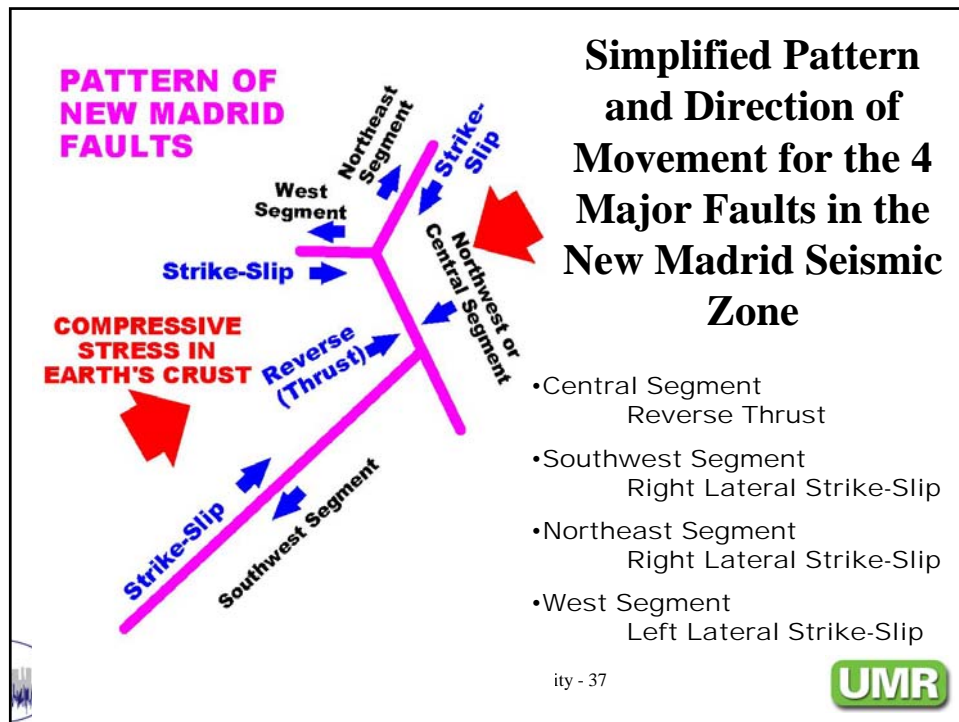
- Both near NMSZ southwest segment strike-slip fault
- One near NMSZ central segment reverse thrust fault

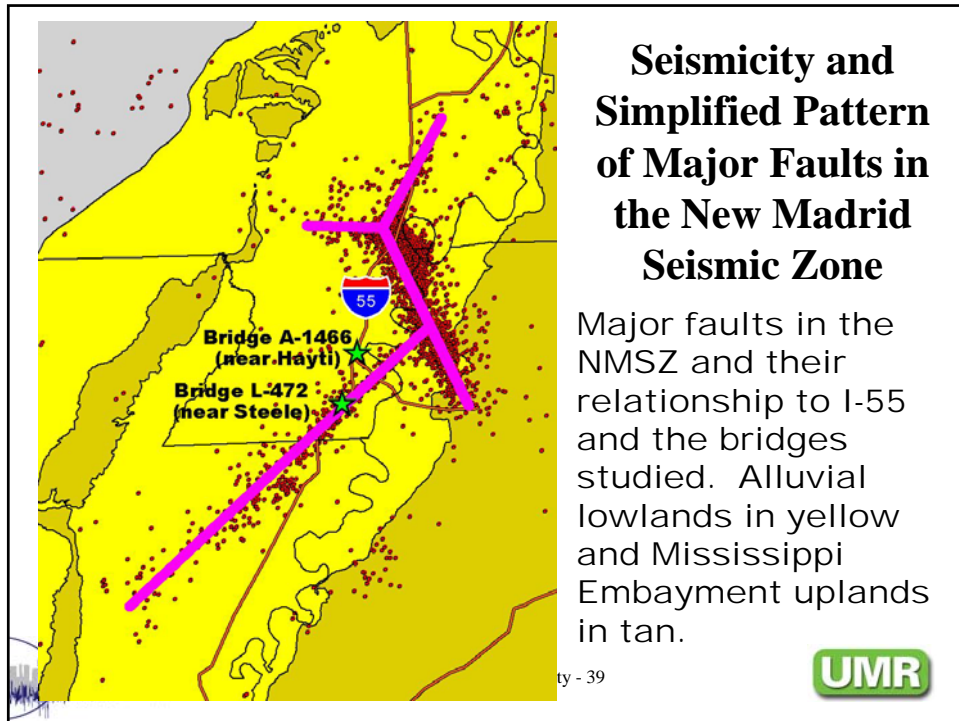


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Sandblows

Evidence of Past Intense Sandblows

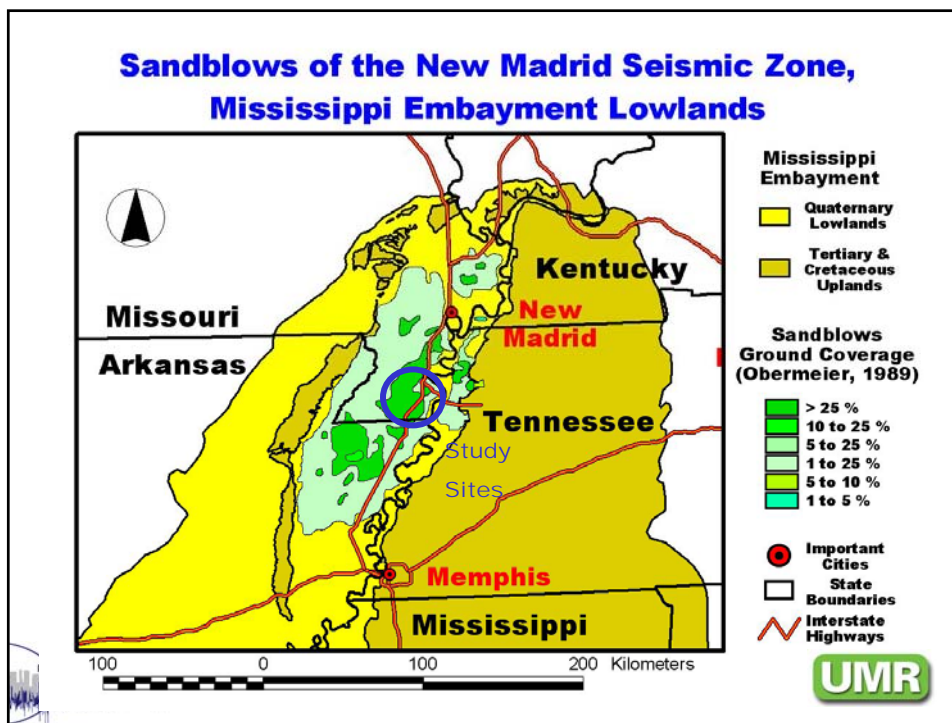
- Casual observation
- Airphoto mapping
- Trench logging

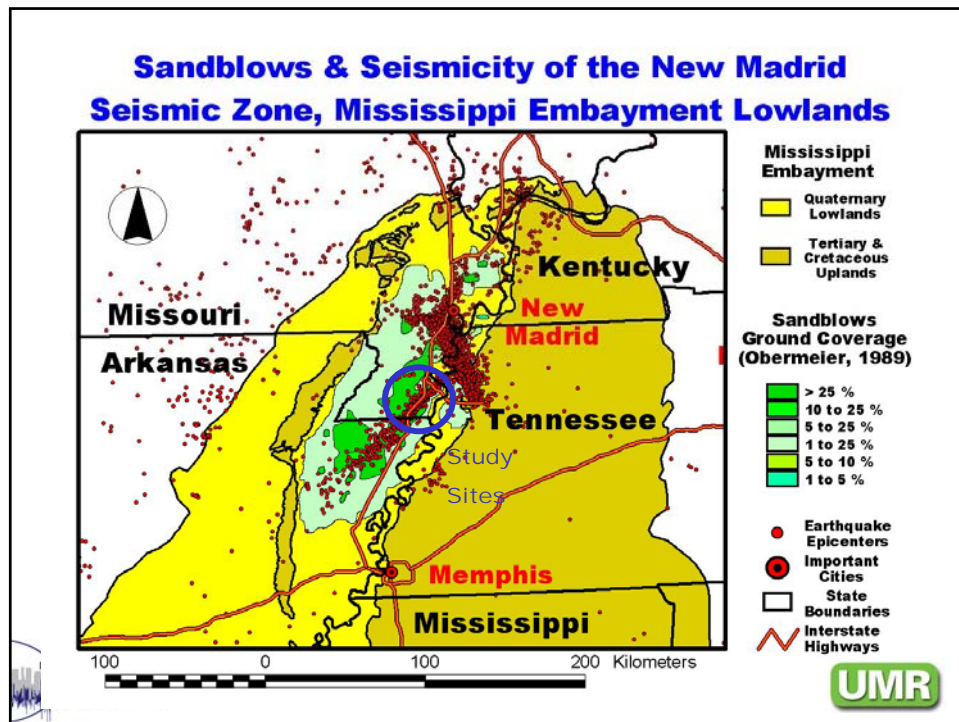
Seismicity Associated with Sandblows

- Close correlation
- Hugh area affected
- Some variation related to local soils and site conditions



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Attenuation

Central & Eastern United States

- Low attenuation
- Ten to twenty times larger shaking intensity area
- Older, harder, dryer bedrock

Western United States

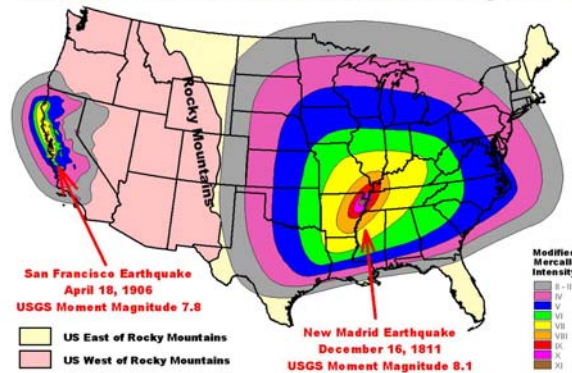
- High attenuation
- Relatively rapid decay of shaking intensity
- Younger, softer, more fractured bedrock



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Modified Mercalli Intensity Areas for Central & Eastern versus Western US Earthquakes



Low seismic wave attenuation properties of the bedrock in the Central and Eastern United States results in much larger areas experiencing any given level of shaking.



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Local site alluvial soils

Alluvial Geology

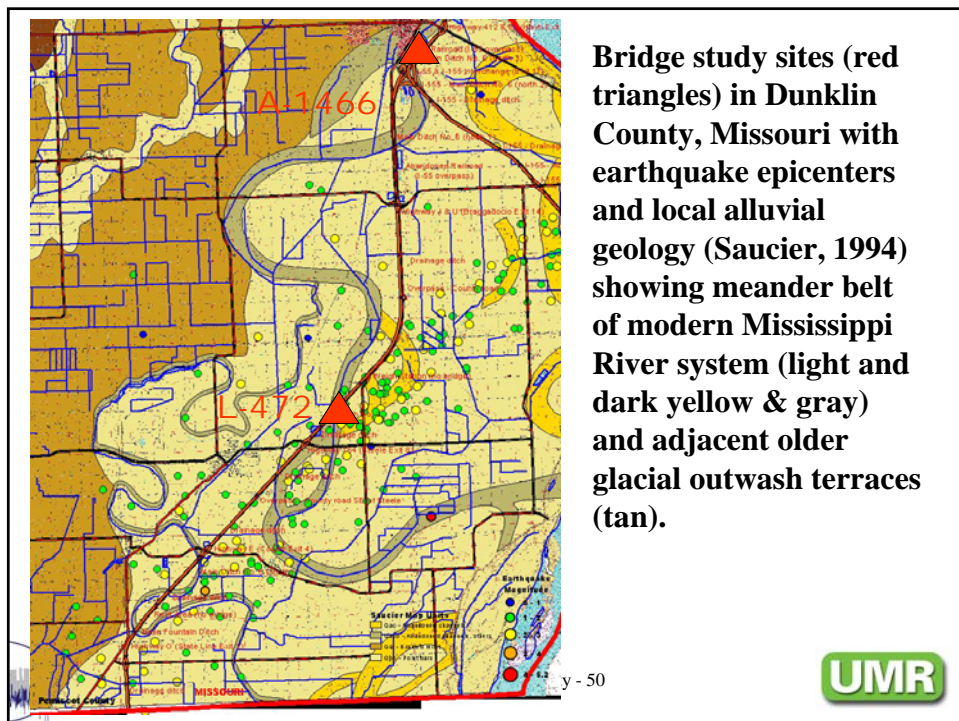
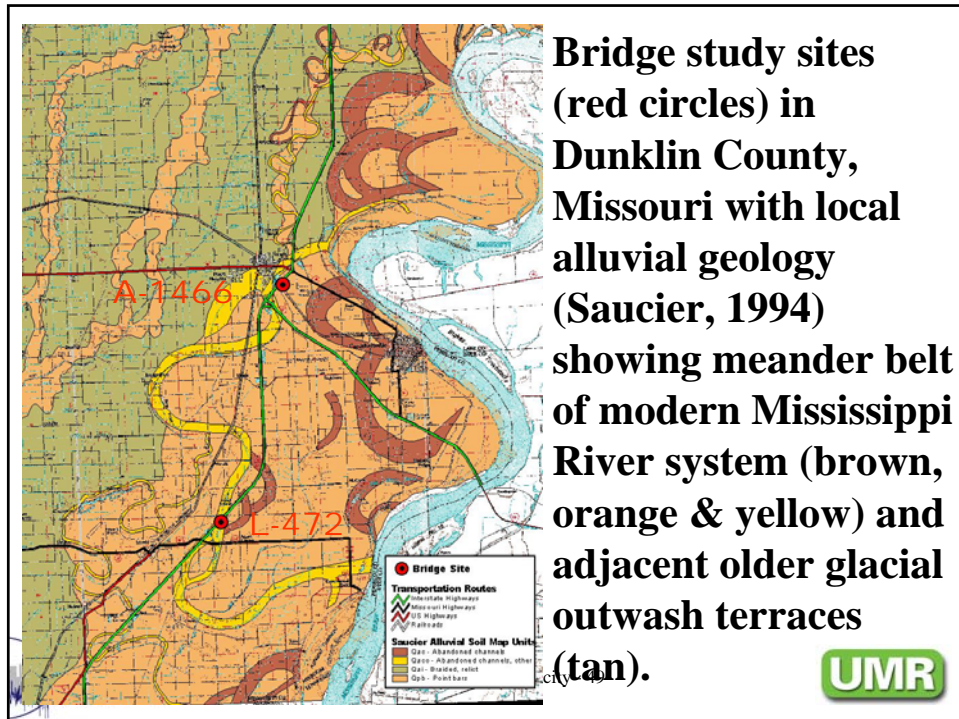
- Saucier (Corps of Engineers) mapping
- Airphoto interpretation
- Some soil boring
- Little or no field work
- Abandoned courses and meanders of the modern Mississippi River
- Glacial outwash terraces or the ancient Ohio and Mississippi Rivers

Seismicity

- Southwest segment of NMSZ at or near bridge sites



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Important Considerations

Past Large New Madrid Earthquakes

- Historic record
- Paleoseismic record

Future New Madrid Earthquake Probabilities

- Magnitude 7.5 to 8.0
- Magnitude larger than 6.0



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Prehistoric and Historic Great New Madrid Earthquakes

(Based on paleoseismology and historic record)

DATE OF LARGE EARTHQUAKE	INTERVAL BETWEEN EARTHQUAKES
~300 AD	~600 years
~900 AD	~550 years
~1450 AD	~350 years
1811 -1812 AD	



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During a 50 year time period the
New Madrid Seismic Zone has a

7 – 10% probability of a M 7.5 – 8.0 earthquake
(the size of the 1811-1812 earthquakes)

OR

25 – 40% probability of a M 6.0 or larger earthquake
(about the size of the 1895 Charleston, Missouri earthquake)



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QUESTIONS?

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