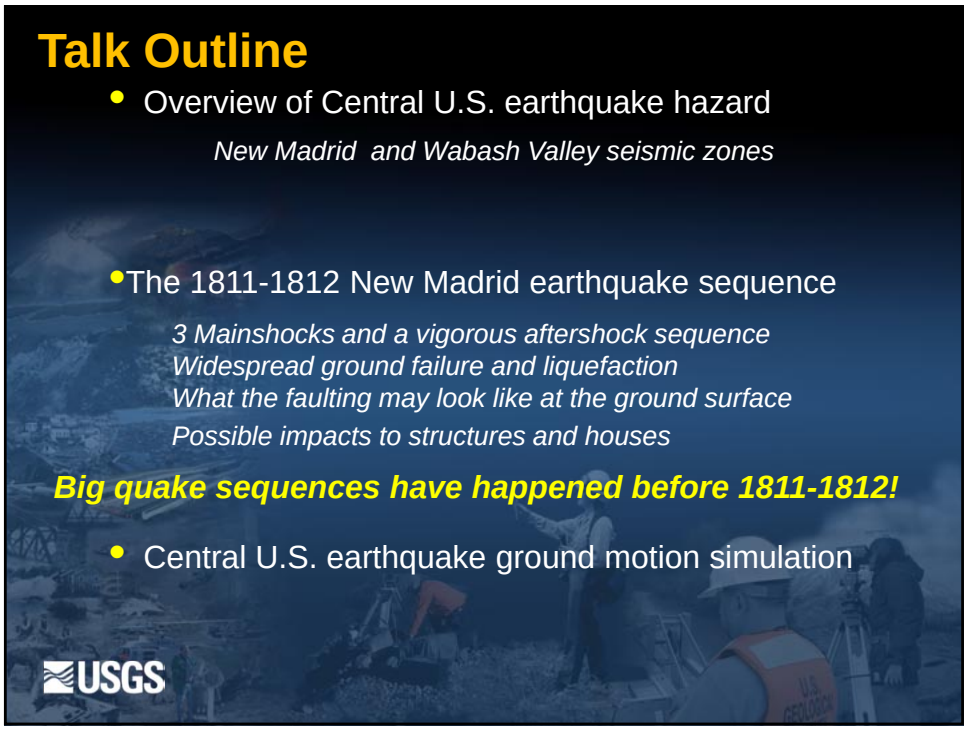
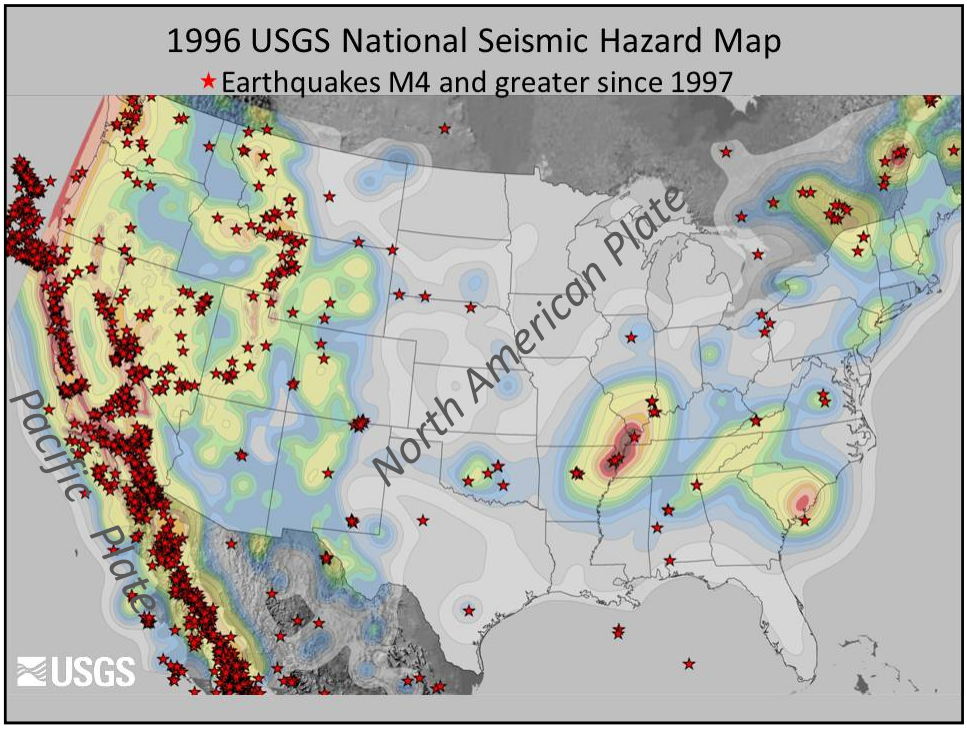
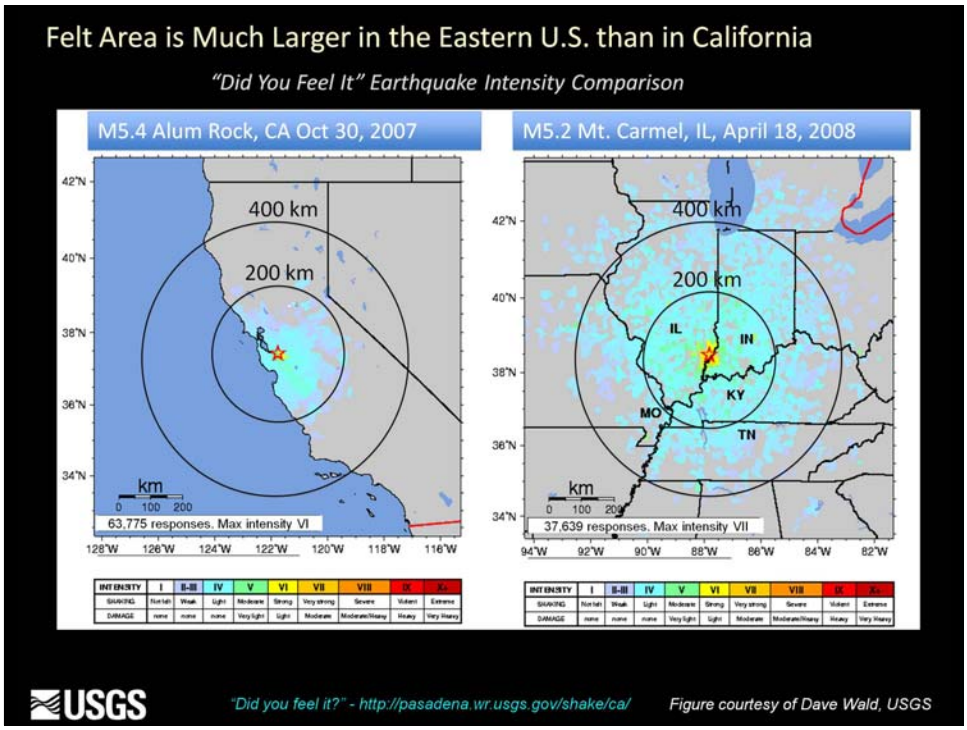

USGS
science for a changing world
The Central U.S. Is Earthquake Country (and it's not just the New Madrid seismic zone)
Rob Williams
U.S. Geological Survey
Golden, CO
April 9, 2012
1811-2011
Bicentennial
New Madrid Earthquake
Understanding in the Future
U.S. Department of the Interior
U.S. Geological Survey


Talk Outline
• Overview of Central U.S. earthquake hazard
New Madrid and Wabash Valley seismic zones
• The 1811-1812 New Madrid earthquake sequence
3 Mainshocks and a vigorous aftershock sequence
Widespread ground failure and liquefaction
What the faulting may look like at the ground surface
Possible impacts to structures and houses
Big quake sequences have happened before 1811-1812!
• Central U.S. earthquake ground motion simulation
USGS


1996 USGS National Seismic Hazard Map
Earthquakes M4 and greater since 1997
North American Plate
Pacific Plate
USGS


Felt Area is Much Larger in the Eastern U.S. than in California
"Did You Feel It" Earthquake Intensity Comparison
M5.4 Alum Rock, CA Oct 30, 2007
400 km
200 km
km
0 100 200
63,775 responses. Max intensity VI
M5.2 Mt. Carmel, IL, April 18, 2008
400 km
200 km
IL
IN
KY
MO
TN
km
37,639 responses. Max intensity VII
USGS
"Did you feel it?" - http://pasadena.wr.usgs.gov/shake/ca/
Figure courtesy of Dave Wald, USGS

New Madrid Seismic Zone

- Setting of the 1811-1812 earthquake sequence
- 3 Mainshocks: each with a vigorous aftershock sequence
- How do we know about the earthquakes?
  - Eye-witness accounts, newspaper articles
  - Widespread ground failure and ***sand blows***
- It's happened before – at least 2 and possibly 3 sequences prior to 1811-1812
- Geologic record of repeated sequences of large earthquakes dominates the hazard

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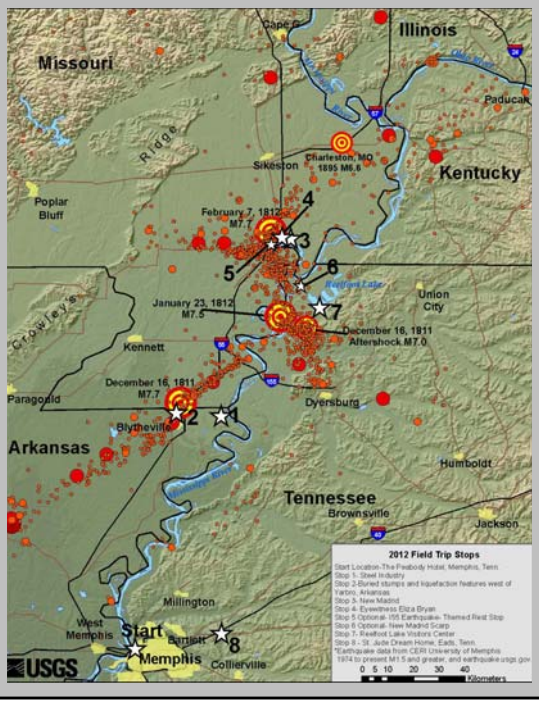
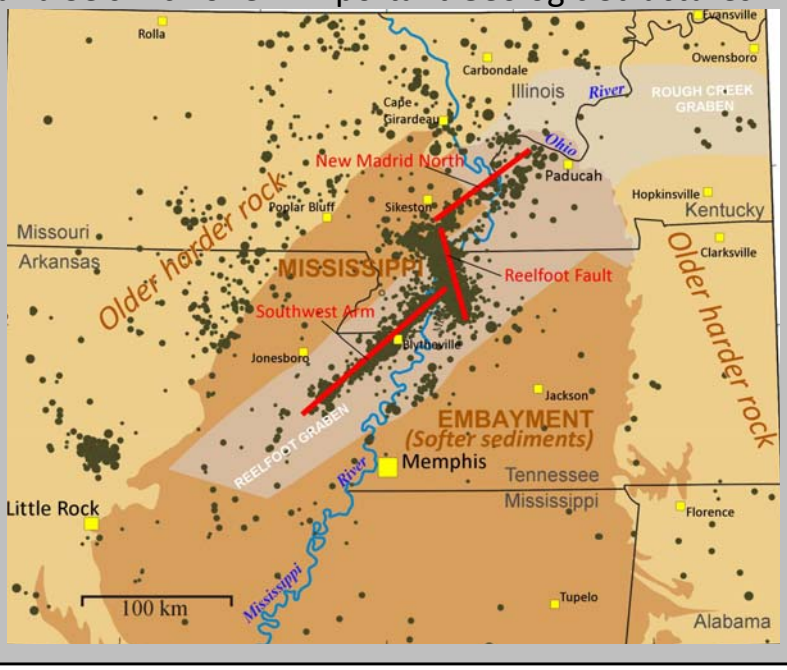
2011 Earthquake Insight Field Trip

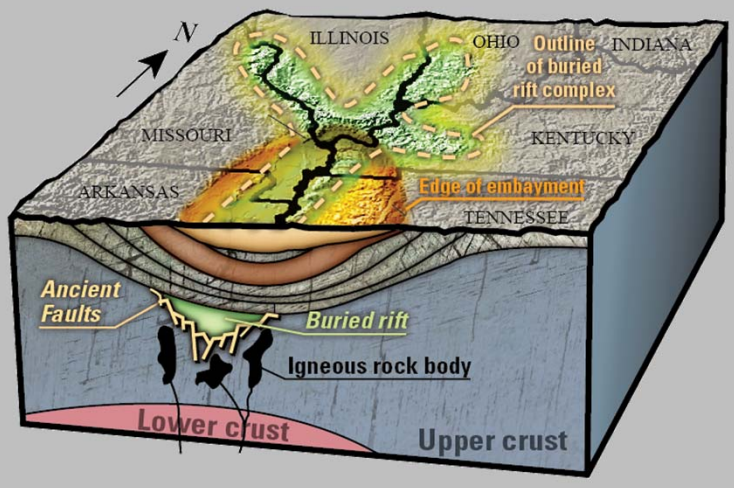
New Madrid Seismic Zone

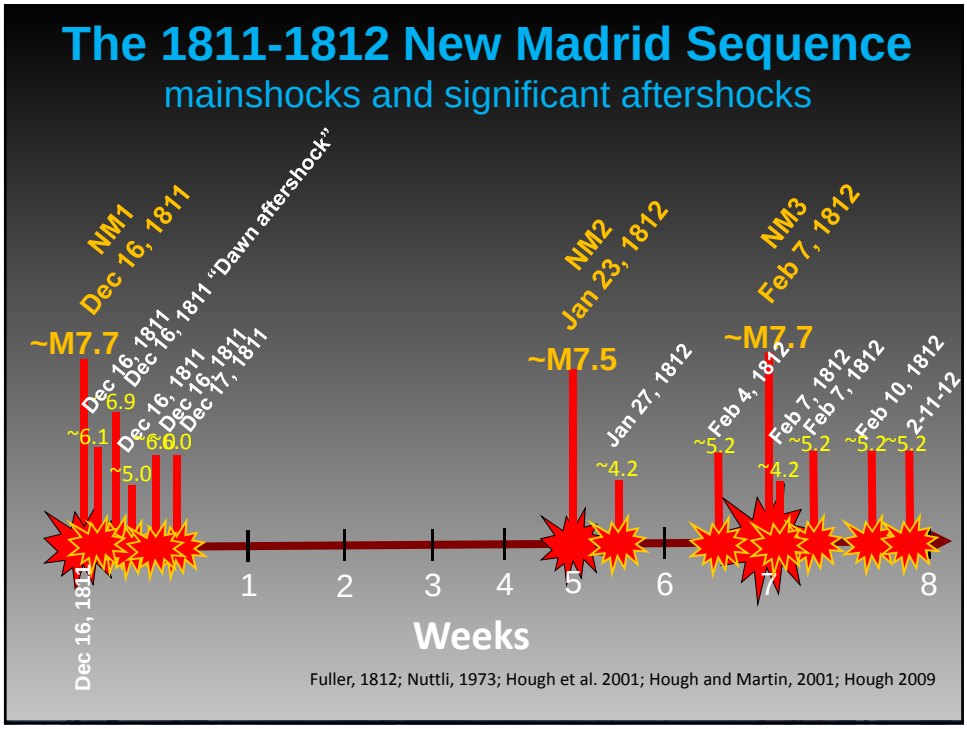


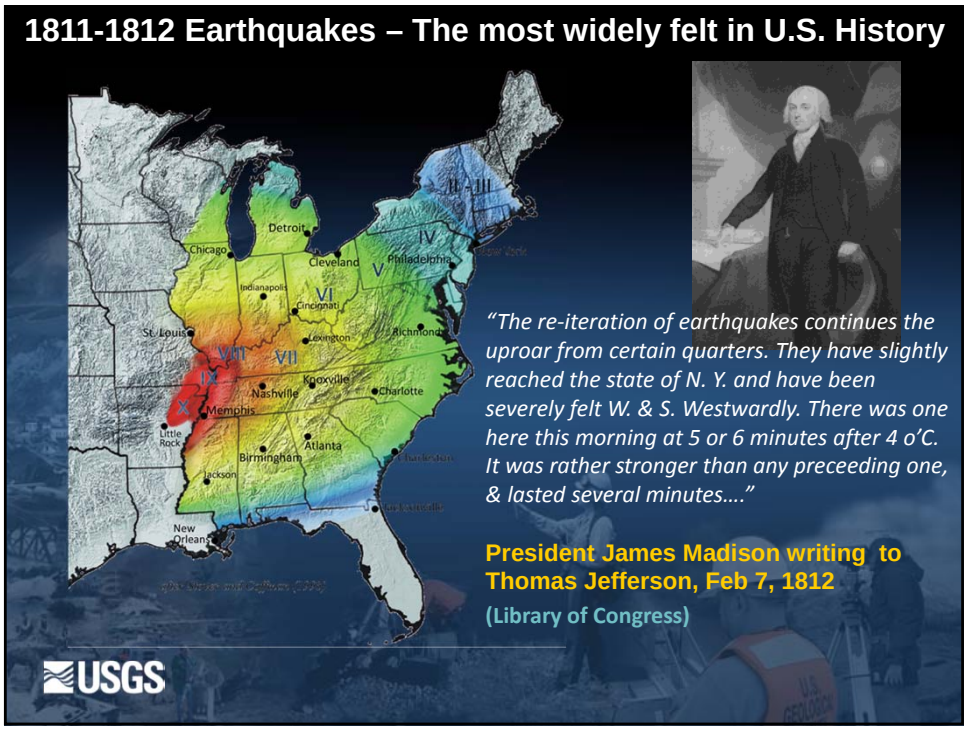
New Madrid Seismic Zone – Important Geologic Structures

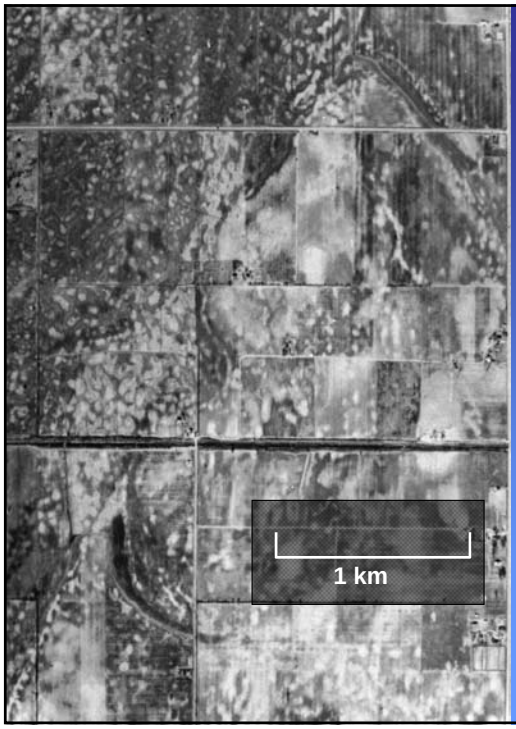


Mississippi Embayment and the Reelfoot Rift




The 1811-1812 New Madrid Sequence
mainshocks and significant aftershocks
NM1
Dec 16, 1811
Dec 16, 1811 "Dawn aftershock"
~M7.7
Dec 16, 1811
6.9
~6.1
Dec 16, 1811
~6.0
~5.0
Dec 16, 1811
Dec 17, 1811
NM2
Jan 23, 1812
~M7.5
Jan 27, 1812
~4.2
NM3
Feb 7, 1812
~M7.7
~Feb 4, 1812
~5.2
Feb 7, 1812
~4.2
~Feb 7, 1812
~5.2
~Feb 10, 1812
~5.2
2-11-12
~5.2
Dec 16, 1811
1
2
3
4
5
6
7
8
Weeks
Fuller, 1812; Nuttli, 1973; Hough et al. 2001; Hough and Martin, 2001; Hough 2009

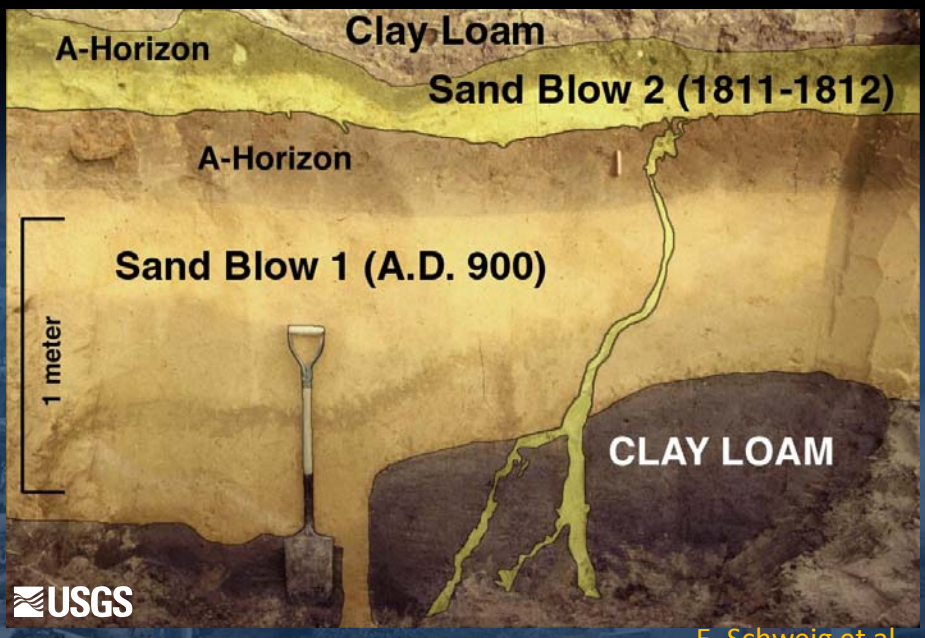

1811-1812 Earthquakes – The most widely felt in U.S. History
Detroit
Chicago
Cleveland
Philadelphia
Indianapolis
Cincinnati
St. Louis
Lexington
Richmond
Knoxville
Nashville
Charlotte
Memphis
Little Rock
Atlanta
Birmingham
Jackson
New Orleans
II - III
IV
V
VI
VII
VIII
IX
X
"The re-iteration of earthquakes continues the uproar from certain quarters. They have slightly reached the state of N. Y. and have been severely felt W. & S. Westwardly. There was one here this morning at 5 or 6 minutes after 4 o'C. It was rather stronger than any preceeding one, & lasted several minutes...."
President James Madison writing to Thomas Jefferson, Feb 7, 1812
(Library of Congress)
USGS



Sand Blows in Southeastern Missouri

- Each white spot is a sand blow from 1811-1812 or earlier earthquakes

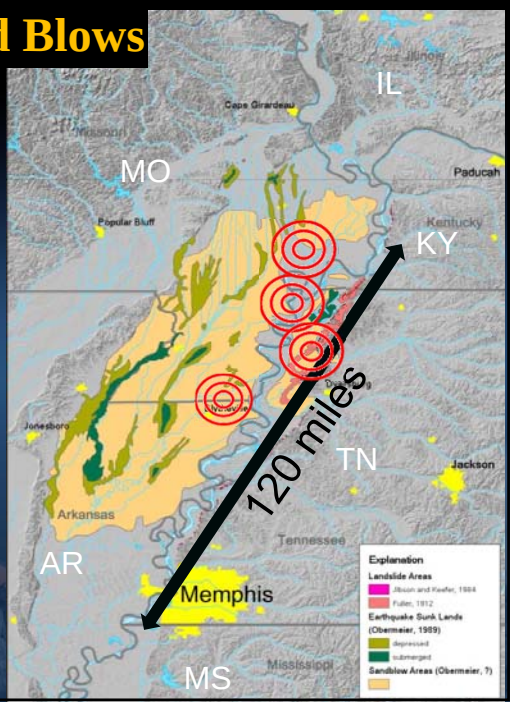
Trench near Charleston, Mo. - Mulitple sand blows



E. Schweig et al.

Liquefaction **and Sand Blows**

Area of 1811-1812 Sand Blows and Liquefaction



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From geologic of the studies of the **New Madrid** region we now know:

- New Madrid Seismic Zone produced large quakes in 1811-12, ~1450 AD, ~900 AD, and ~2350 BC
- The average time between these events is about 500 years at least during past 1200 years
- The prehistoric earthquakes were similar in size to the 1811-1812 earthquakes
- Each New Madrid event was a sequence of earthquakes, including multiple very large mainshocks, much like the 1811-1812 sequence

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What are the hazards?

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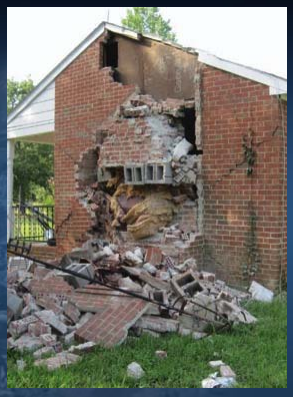
From David Johnston, Ark Geol. Survey

What are the hazards?

And Ground Shaking



Virginia
August 2011
Zone of severe structural damage ~7 miles from epicenter

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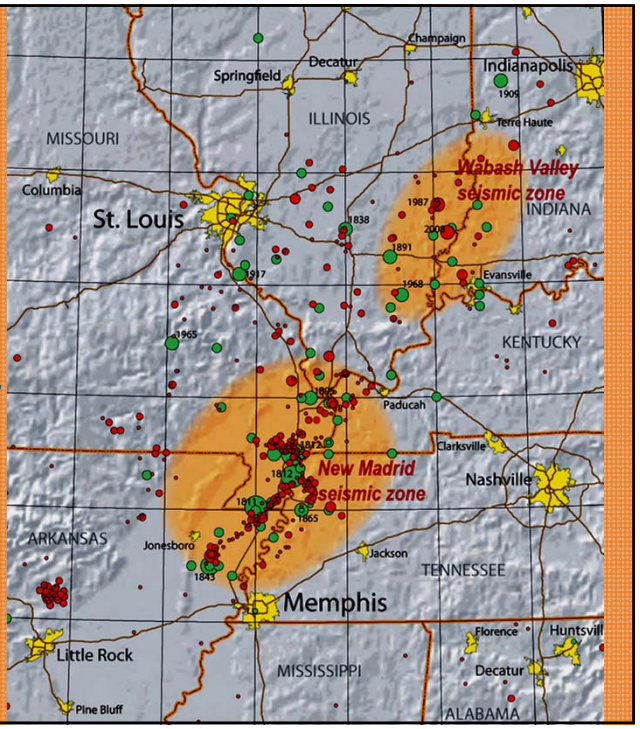
Other Seismic Zones:

Wabash Valley

South-Central Illinois-Missouri



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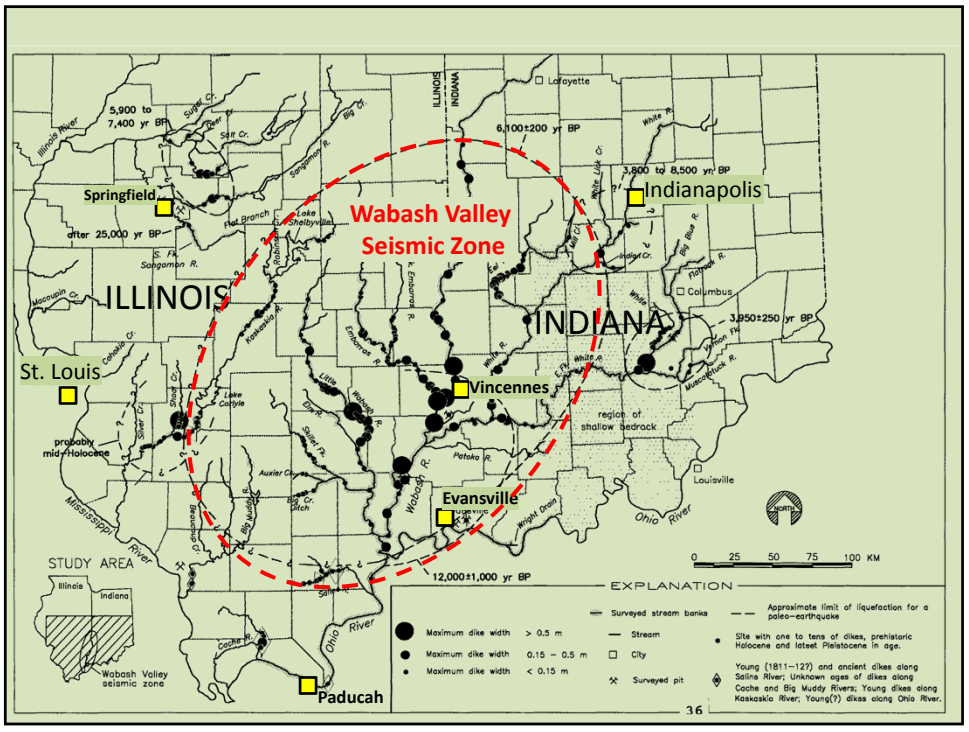

Wabash Valley Seismic Zone – Earthquake History

- Less active than the New Madrid seismic zone but three M5-M5.5's in the last 43 years.
- Prehistoric earthquake history determined from sand blows.
- Hundreds of sand dikes have been found dating to within the last 10,000 years. (Munsun et al., 1994; Obermeier 1996)
- Age dating at widespread sites show that most liquefaction features resulted from a single earthquake 6100+/- 200 years ago and it was about M7.5. (Munson et al. 1992, 1994)
- The next strongest quake occurred about 12,000 years ago

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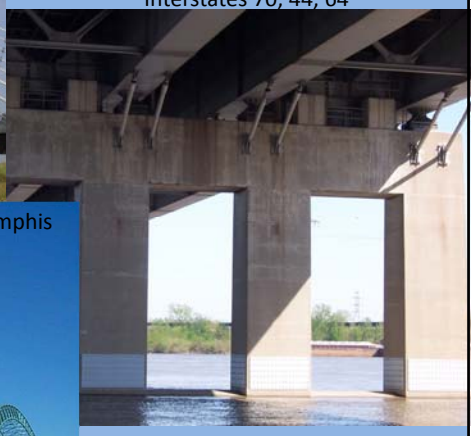
Mississippi River Bridges

Bill Emerson Memorial
Cape Girardeau, Mo.

Poplar Street Bridge – St. Louis
Interstates 70, 44, 64



Hernando De Soto – Memphis
Interstate 40

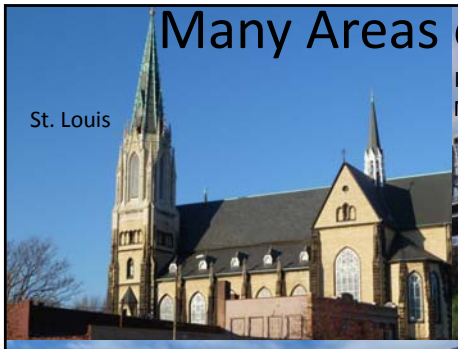
USGS

2000_9_28

20

Many Areas of Concern

St. Louis

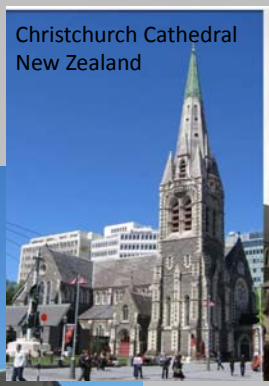


Interstate 55
Memphis

Christchurch Sept 2010

Main Streets in the Eastern U.S.

Christchurch Cathedral
New Zealand



After M7.0 and M6.1

St. Louis

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We've learned a lot in the last 30 years but we still have a long way to go:

- When did the earthquakes start?
- Do big earthquakes move around the NMSZ?
- Why do big quakes happen here (Earthscope)?
- More Paleoseismology outside the NMSZ
- Will future big quakes repeat on same faults?
- What do recurrence times look like over 20,000-100,000 years?
- Liquefaction impacts in future large quakes?
- Variability of ground motions

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Reelfoot Lake
Tennessee

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Most earthquakes occur along plate boundaries but not all of them!

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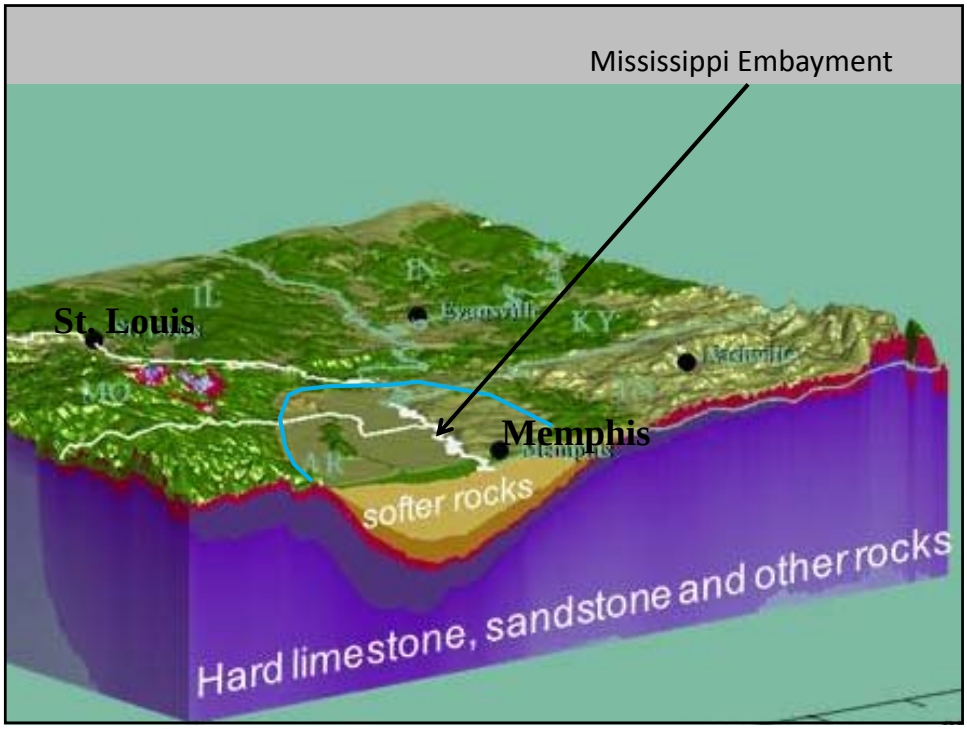
Seismicity of the US, 1977-1997



Summary of the hazard

- Currently producing earthquakes; most active zone in eastern North America
- We cannot predict earthquakes; but it is reasonable and prudent to expect NMSZ to behave as it has in recent past
- A magnitude-7+ earthquake is a low-probability, high-consequence event; a magnitude-6.0+ earthquake has higher probability and also can cause significant damage
- Broad agreement in earth science community that NMSZ continues to pose a significant and ongoing hazard

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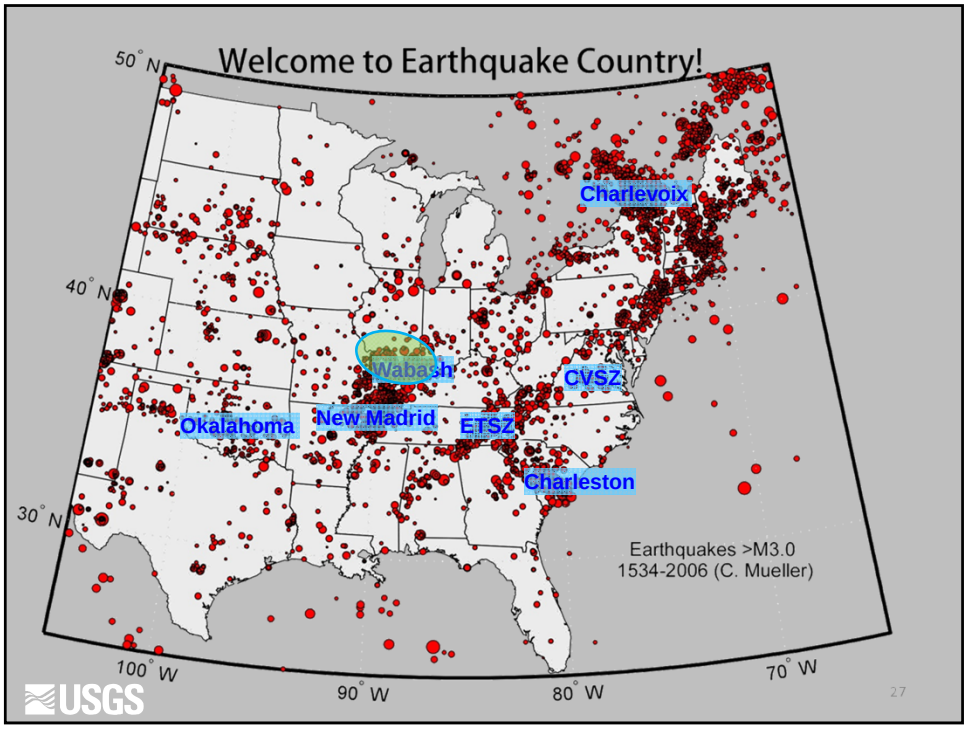
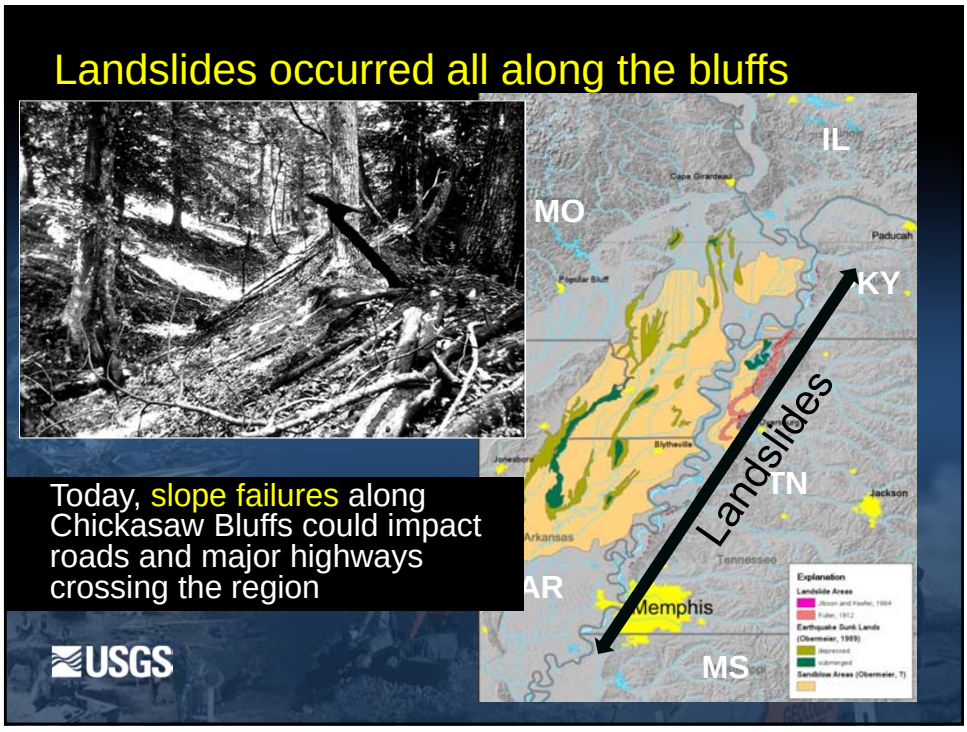

Welcome to Earthquake Country!
50° N
40° N
30° N
100° W
90° W
80° W
70° W
Charlevoix
Wabash
CVSZ
Okalahoma
New Madrid
ETSZ
Charleston
Earthquakes >M3.0
1534-2006 (C. Mueller)
USGS
27


Landslides occurred all along the bluffs
Today, slope failures along Chickasaw Bluffs could impact roads and major highways crossing the region
IL
MO
KY
TN
AR
MS
Memphis
Landslides
Paducah
Jackson
Explanation
USGS