The Central U.S. Is Earthquake Country (and it’s not just the New Madrid seismic zone)

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April 9, 2012

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
1996 USGS National Seismic Hazard Map

*Earthquakes M4 and greater since 1997*

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

M5.2 Mt. Carmel, IL, April 18, 2008

“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

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

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

“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)
Sand Blows in Southeastern Missouri

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

Trench near Charleston, Mo. - Multiple sand blows

- A-Horizon
- Clay-Loam
- Sand Blow 2 (1811-1812)
- Sand Blow 1 (A.D. 900)
- CLAY LOAM

E. Schweig et al.
From geologic 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
What are the hazards?

From David Johnston, Ark Geol. Survey

Riverbank collapse

Land Subsidence

Landslides

Liquefaction

What are the hazards?

And Ground Shaking

Virginia

August 2011
Zone of severe structural damage
~7 miles from epicenter
Other Seismic Zones:

**Wabash Valley**

**South-Central Illinois-Missouri**
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

Mississippi River Bridges

Bill Emerson Memorial Cape Girardeau, Mo.

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

Hernando De Soto – Memphis Interstate 40
Many Areas of Concern

St. Louis

Christchurch Sept 2010

Main Streets in the Eastern U.S.

Interstate 55

Memphis

Christchurch Cathedral

New Zealand

After M7.0 and M6.1

St. Louis
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

Most earthquakes occur along plate boundaries but not all of them!
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
Landslides occurred all along the bluffs

Today, slope failures along Chickasaw Bluffs could impact roads and major highways crossing the region.