Teaching about New Madrid earthquakes: science and hazard

Illinois Earthscope Teachers' Workshop

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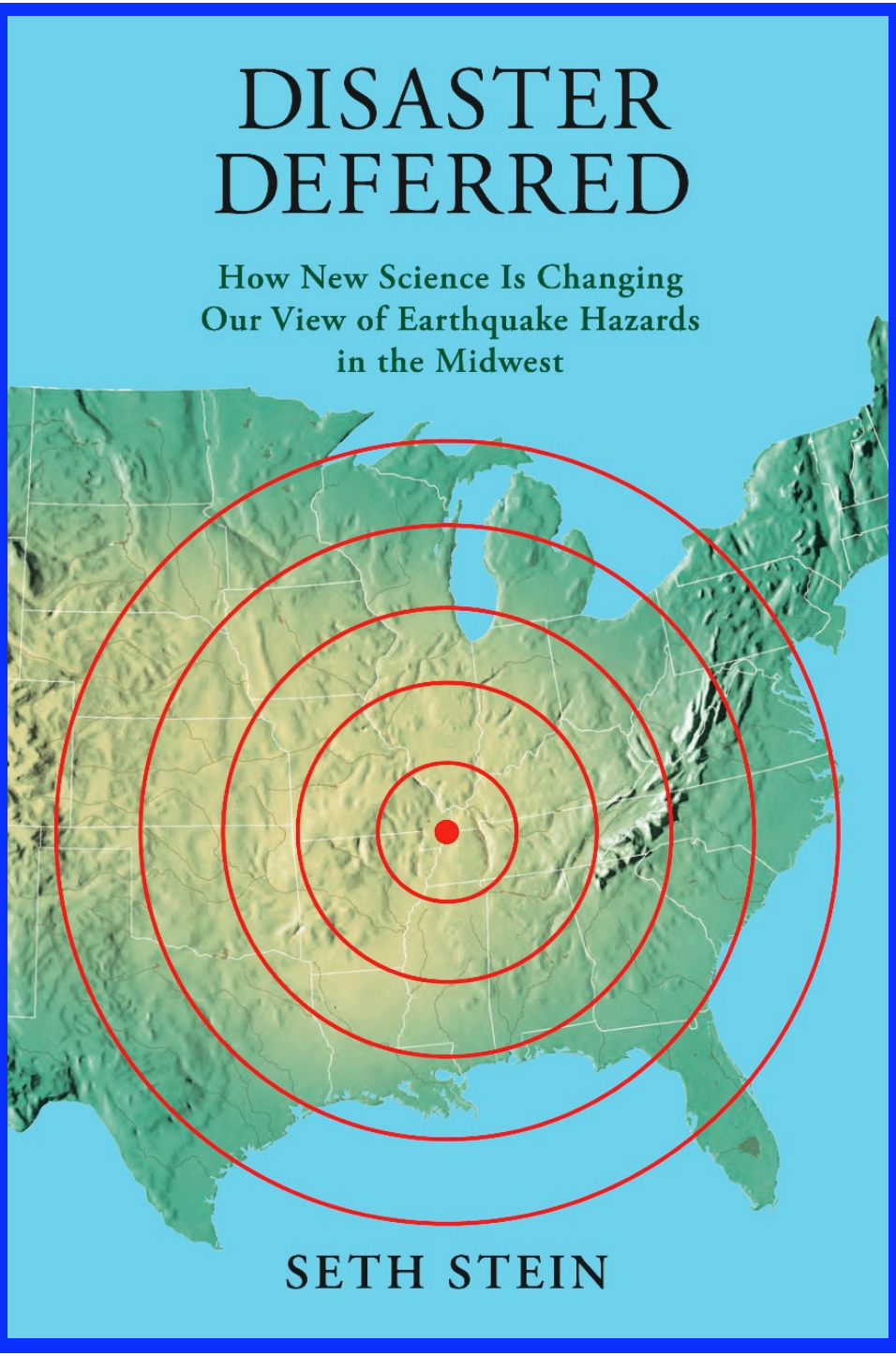
Northwestern University



Why this is a exciting problem

What we know

What we don't

What we suspect

How we try to learn more

"Half of what we will teach you in the next few years is wrong. The problem is we don't know which half"

Medical school dean to incoming students

1. Introduction to the NMSZ
2. The 1811-1812 earthquakes
3. Disasters, pseudodisasters, and critical thinking
4. How the ground shakes
5. How earthquakes work
6. Earthquakes that shouldn’t happen
7. What's going on at New Madrid?
8. Faults switching on and off
9. As dangerous as California?
10. What to do?

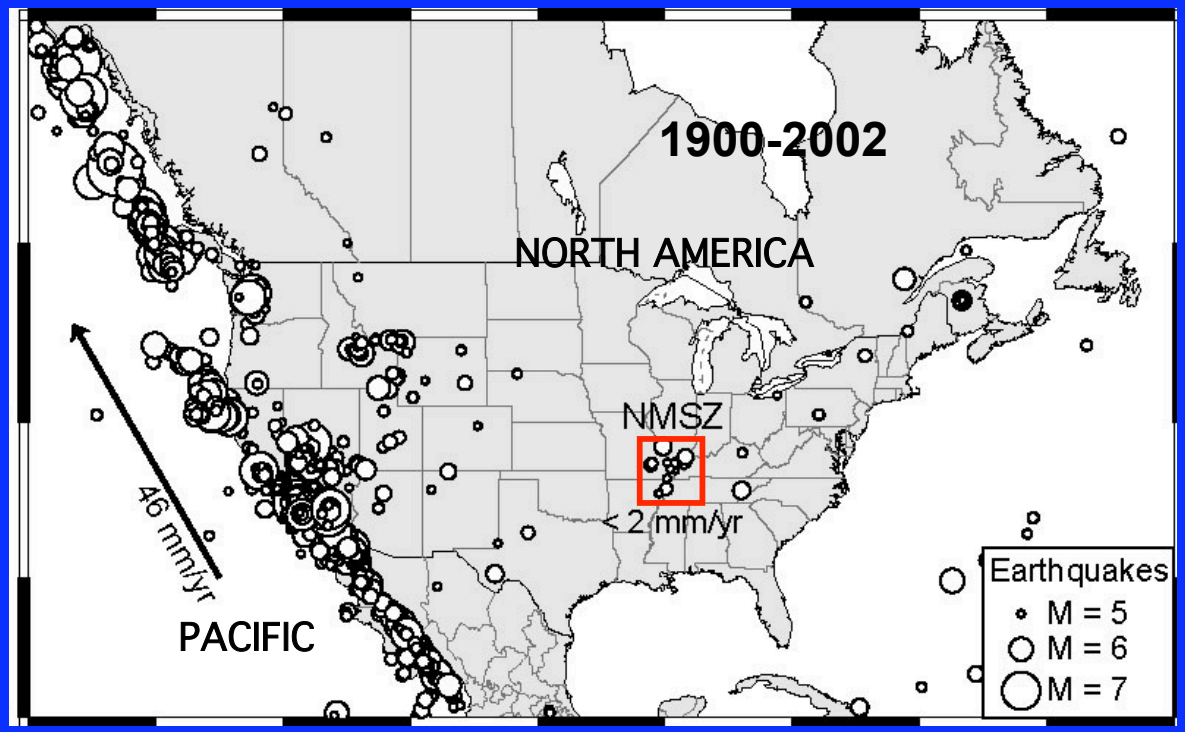
New Madrid seismic zone

M 7 earthquakes in 1811-12

Small quakes continue (M>6 about every 175 years) with little damage

Big ones might happen again

Questions: why, when, how dangerous



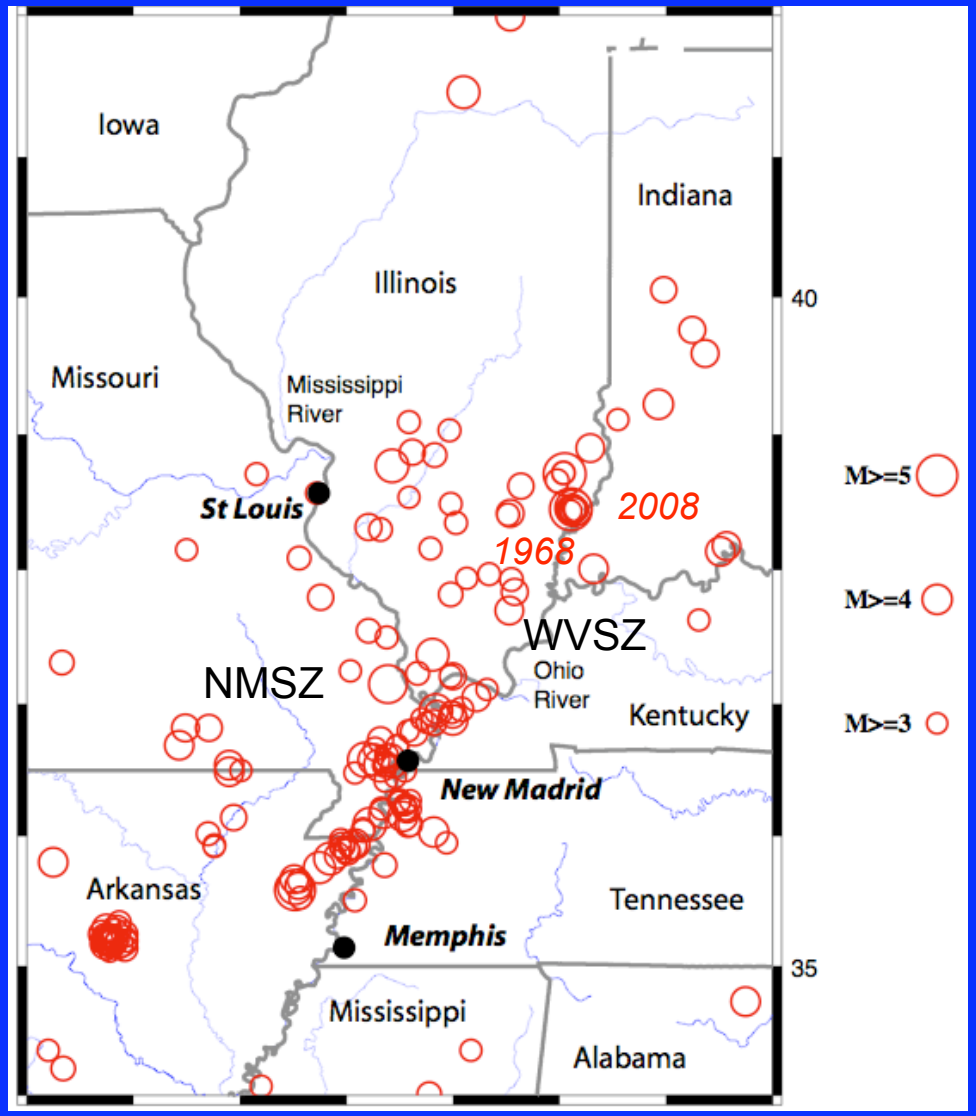
Type example of continental midplate seismicity

Midwest earthquakes 1975-2008

Concentration around New Madrid, mostly aftershocks defining faults that broke in large 1811-12 events

Lesser concentration in Wabash Valley seismic zone

Surrounded by diffuse regional “cloud”



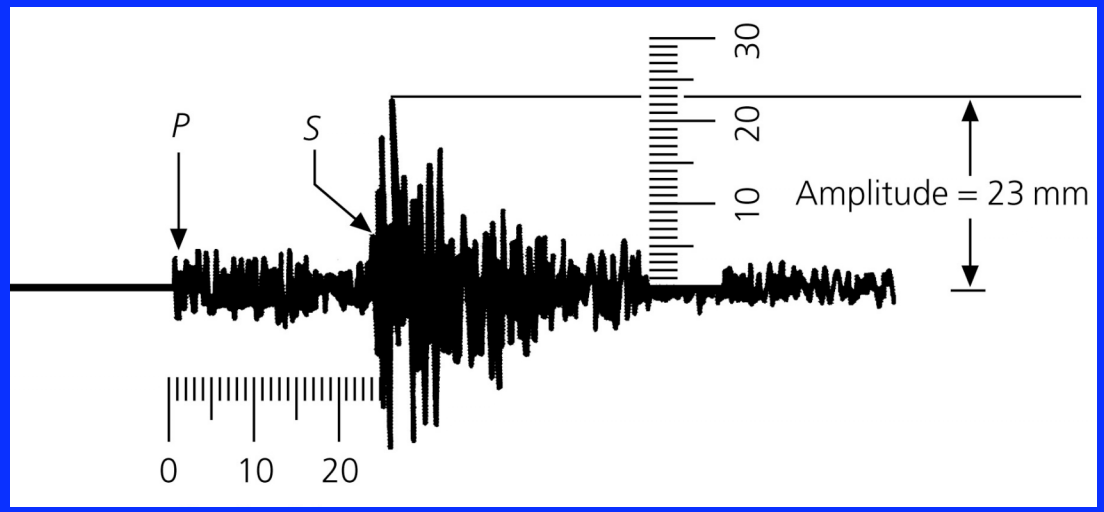
EARTHQUAKE MAGNITUDE

Earliest measure of earthquake size

Dimensionless number measured from seismogram various ways, including

M_L local magnitude
m_b body wave magnitude
M_s surface wave magnitude
M_w moment magnitude

M_w directly tied to physics of faulting



General form of Magnitude scales:

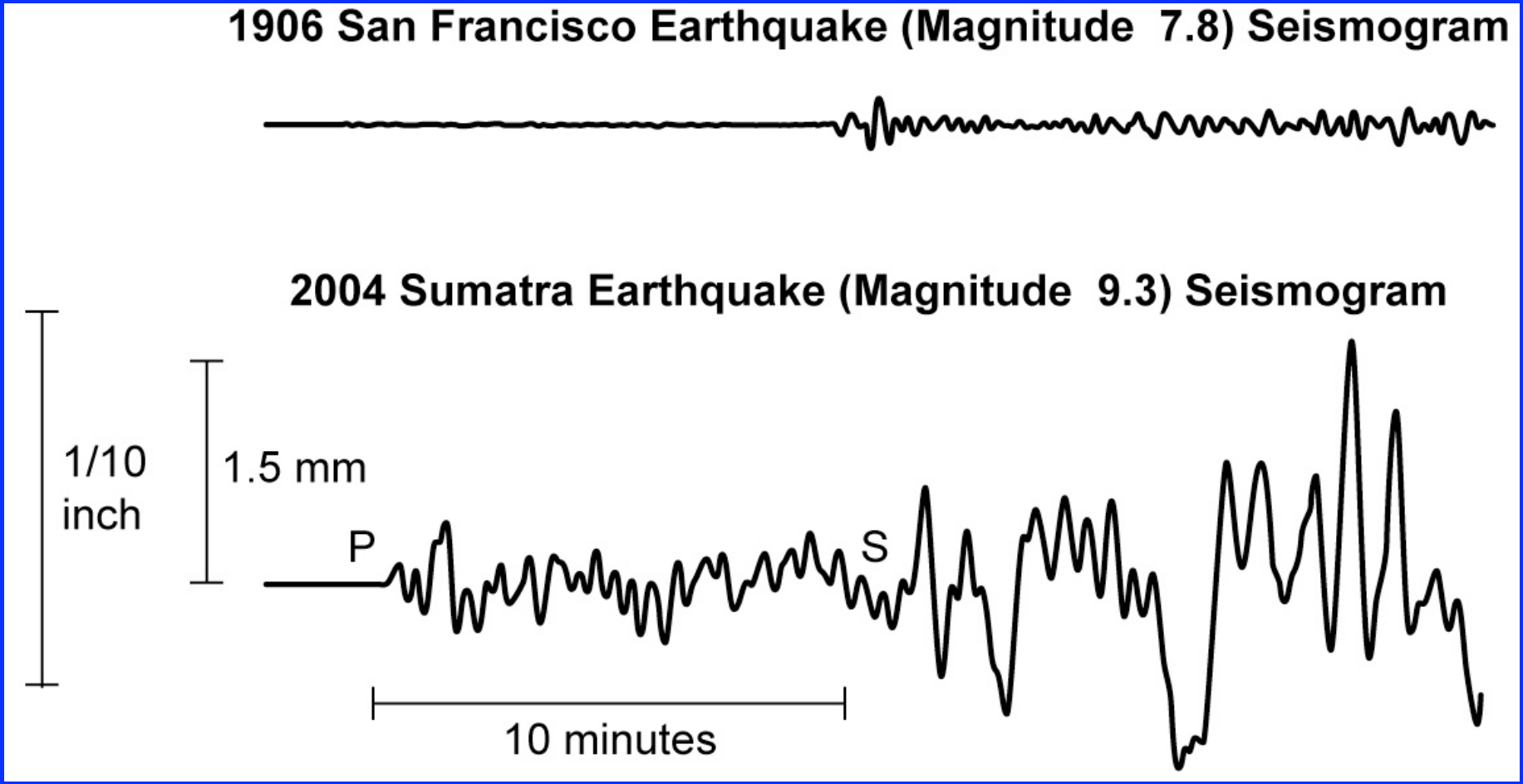
$$M = \log(A/T) + F(h, \Delta) + C$$

A is the amplitude of the signal

T is its dominant period

F is a correction for the variation of amplitude with the earthquake's depth h and distance Δ from the seismometer

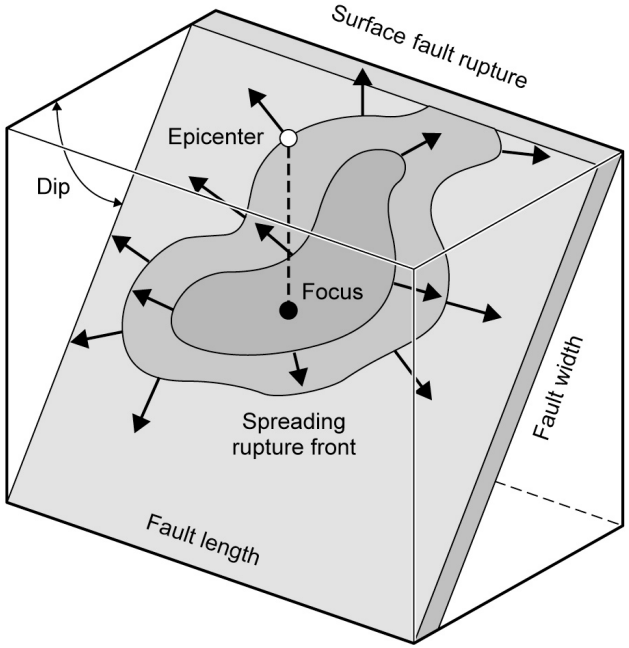
C is a regional scale factor

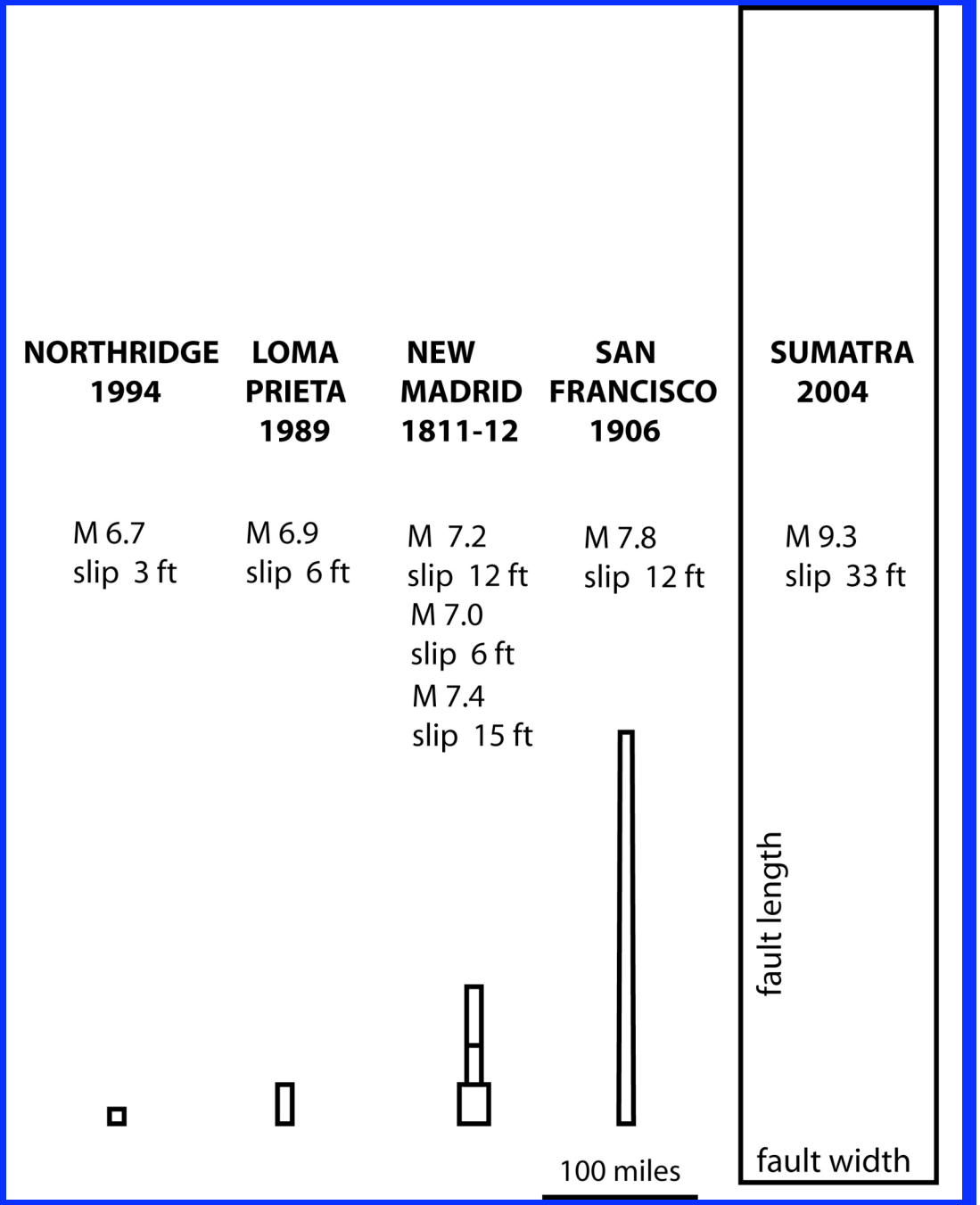

1906 San Francisco Earthquake (Magnitude 7.8) Seismogram
2004 Sumatra Earthquake (Magnitude 9.3) Seismogram
1/10 inch
1.5 mm
P
S
10 minutes

R. Aster

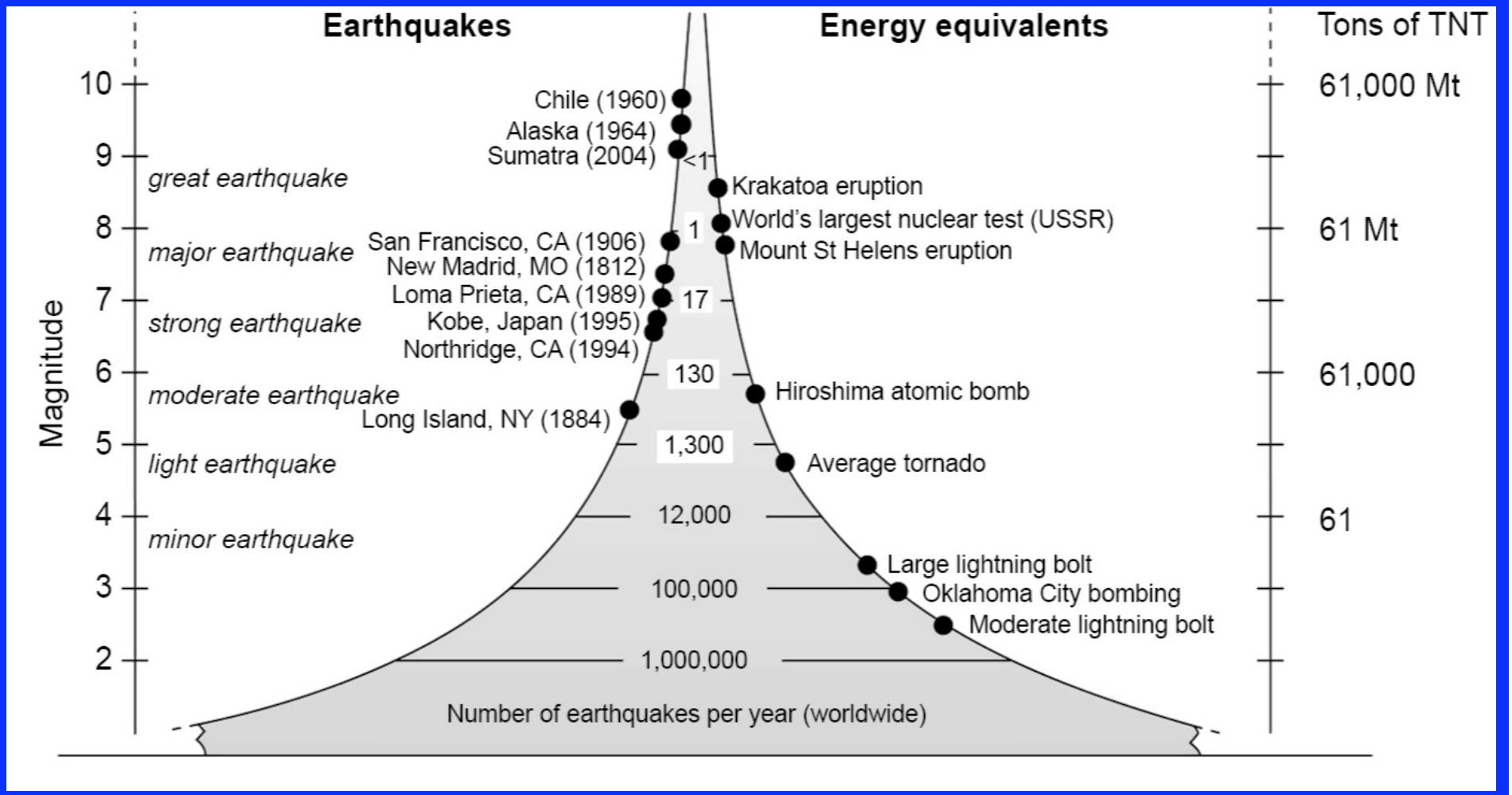
DD 8.3

Bigger earthquakes involve more slip on larger faults





Bigger earthquakes are less frequent



Earthquakes of a given magnitude are about 10 times less frequent than ones a magnitude unit larger

IRIS

DD 8.6

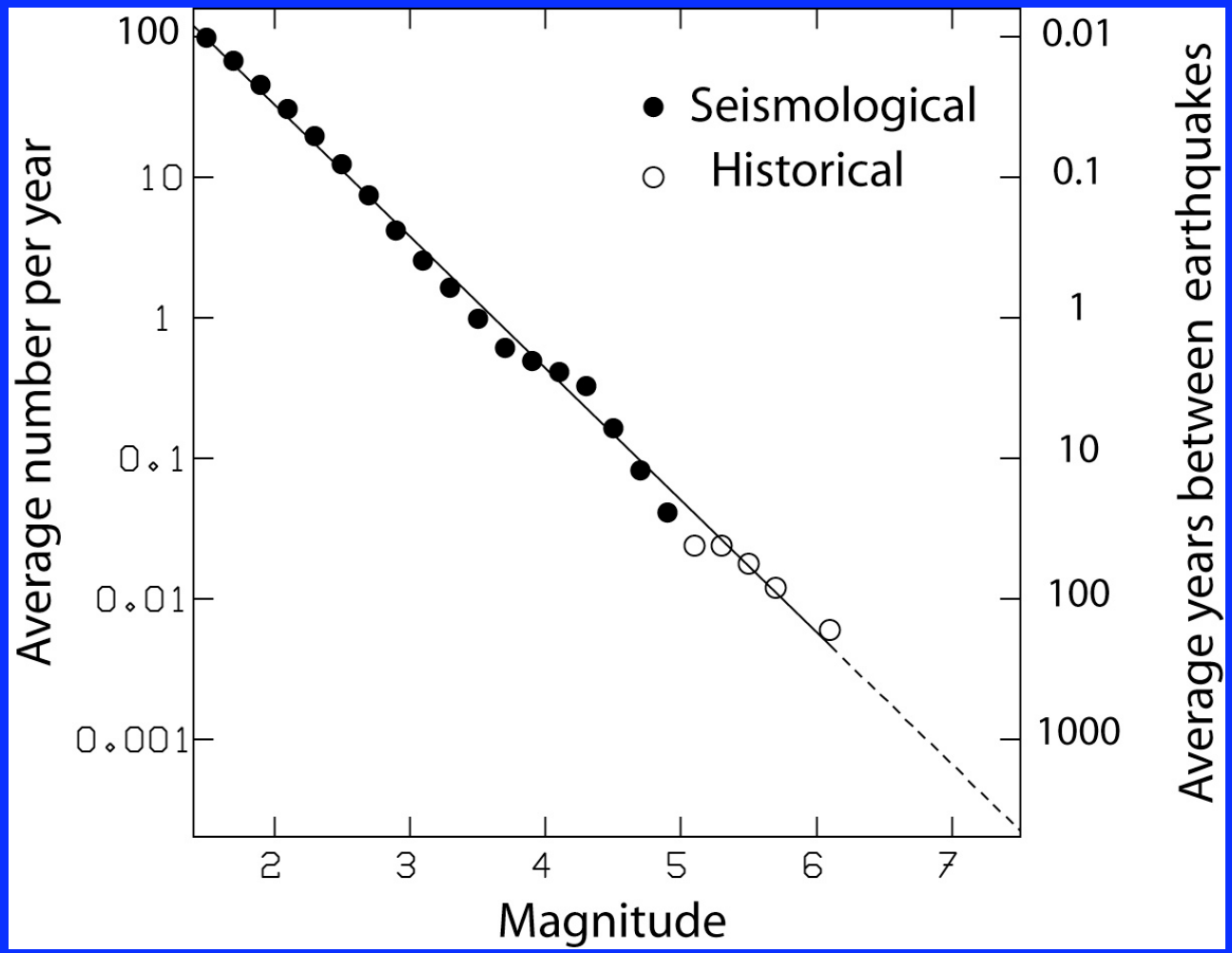
How often do New Madrid zone earthquakes occur?

Log-linear plot
log N = a - bM

where N is number of earthquakes with magnitude >= M

One M > 5 about every 20 years

One M>6 about every 175 years

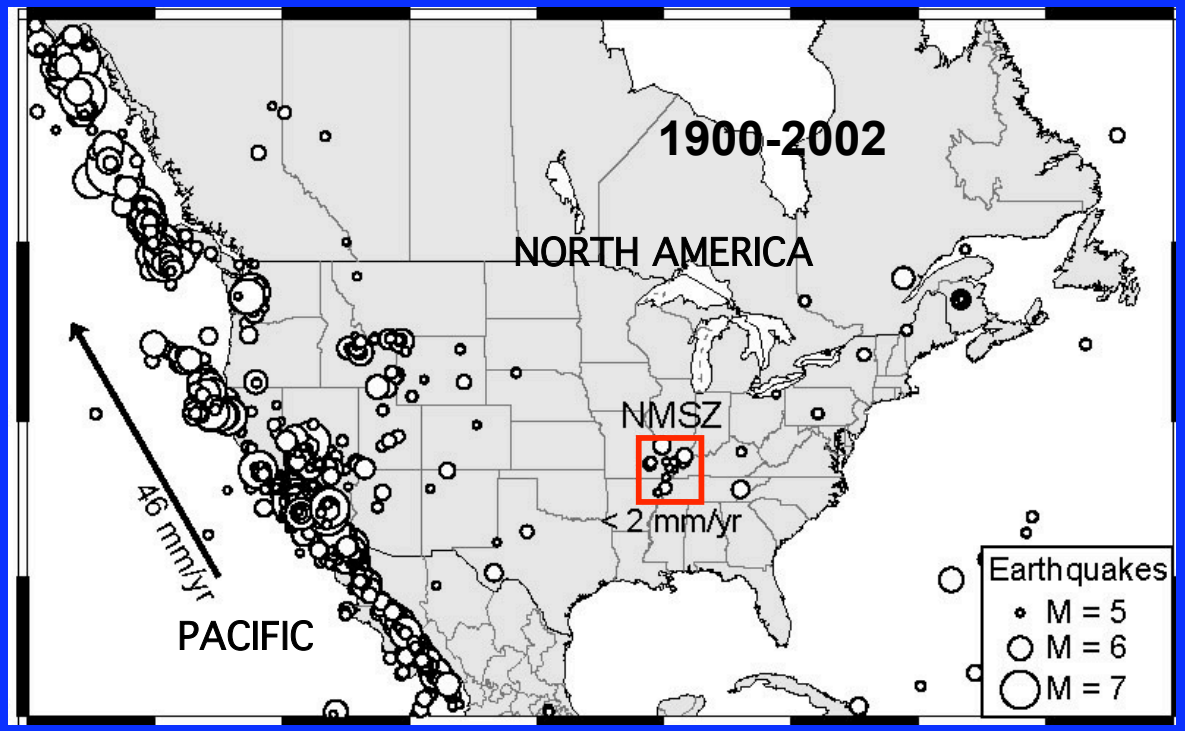


Activity 1.1

California vs New Madrid

Since 1816 southern California has had about 180 earthquakes with M greater than or equal to 6 and 25 with M greater than or equal to 7

Calculate how frequent M5 and M6 are and compare them to New Madrid



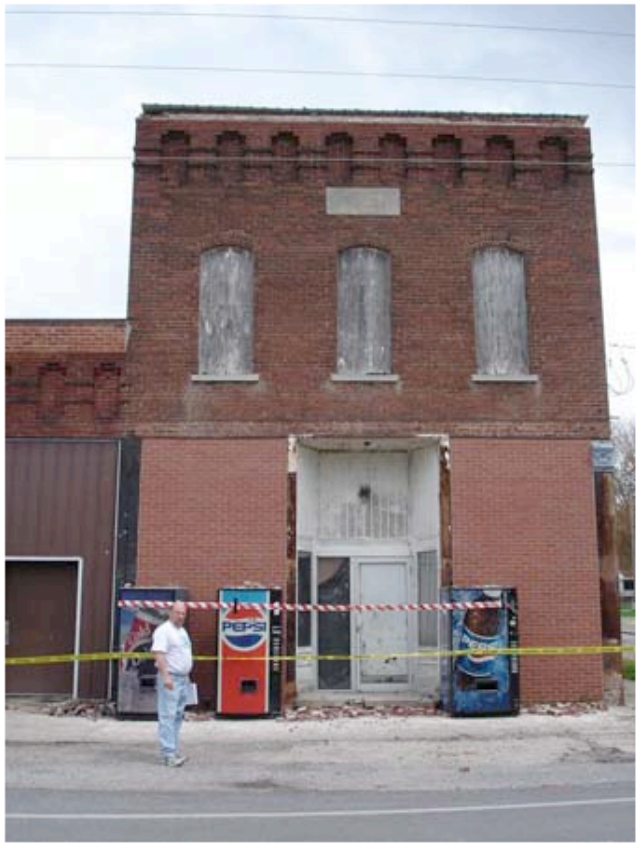
Largest in past century, 1968 (M 5.5) southern Illinois earthquake, caused no fatalities. Damage consisted of fallen bricks from chimneys, broken windows, toppled television aerials, and cracked or fallen brick & plaster.

Vertical crack in west side of accelerator tank of Texaco Flood Station, Dale. - *D.W.G.*
(Saint Louis University Archives)

A large 2-story brick house, 3 1/2 miles west of Dale. Front porch had been pulled several inches away from the house. - *R.B.H.*
(Saint Louis University Archives)

April 2008 M 5.2

A wider view of the 1904 Berry School, Mt. Carmel, Illinois, shows the collapsed chimney, bricks missing from the wall, and bricks missing from the a-frame.
- *Mary Seid, I.S.G.S.*



ISGS geologist Joe Devera stands in front of the damaged 1899 town hall on Hackberry and Main, Belmont, Illinois.
- *Mary Seid, I.S.G.S.*

In West Salem, a few miles from the epicenter of Friday's quake, some residents took the uproar in stride. Bill Harrison, 76, who's lived through a few similar temblors, calmly waved at cars as he sat in front of a window shattered by the morning rumble. "It's not too much to get excited about," Harrison said. "The ground's shook before and it'll shake again." (Chi. Tribune)

MODIFIED MERCALLI INTENSITY SCALE

Describes shaking & its effects

Proportional to ground acceleration (g)

Estimated for historic earthquakes from accounts of what happened

I. Shaking not felt, no damage: Not felt except by a very few under especially favorable circumstances.

II. Shaking weak, no damage: Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated.

IV. Shaking light, no damage: During the day felt indoors by many, outdoors by very few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably. (0.015g-0.02g)

V. Shaking moderate, very light damage: Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees and poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (0.03g-0.04g)

VI. Shaking strong, light damage: Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight. (0.06g-0.07g)

VII. Shaking very strong, moderate damage: Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars. (0.10g-0.15g)

VIII. Shaking severe, moderate to heavy damage: Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed. (0.25g-0.30g)

IX. Shaking violent, heavy damage: Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (0.50g-0.55g)

X. Shaking extreme, very heavy damage: Some well-build wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks. (More than 0.60g)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level destroyed. Objects thrown into the air.

Activity 1.2: Did you feel it?

Where do you live?

Did you feel the 2008 earthquake?

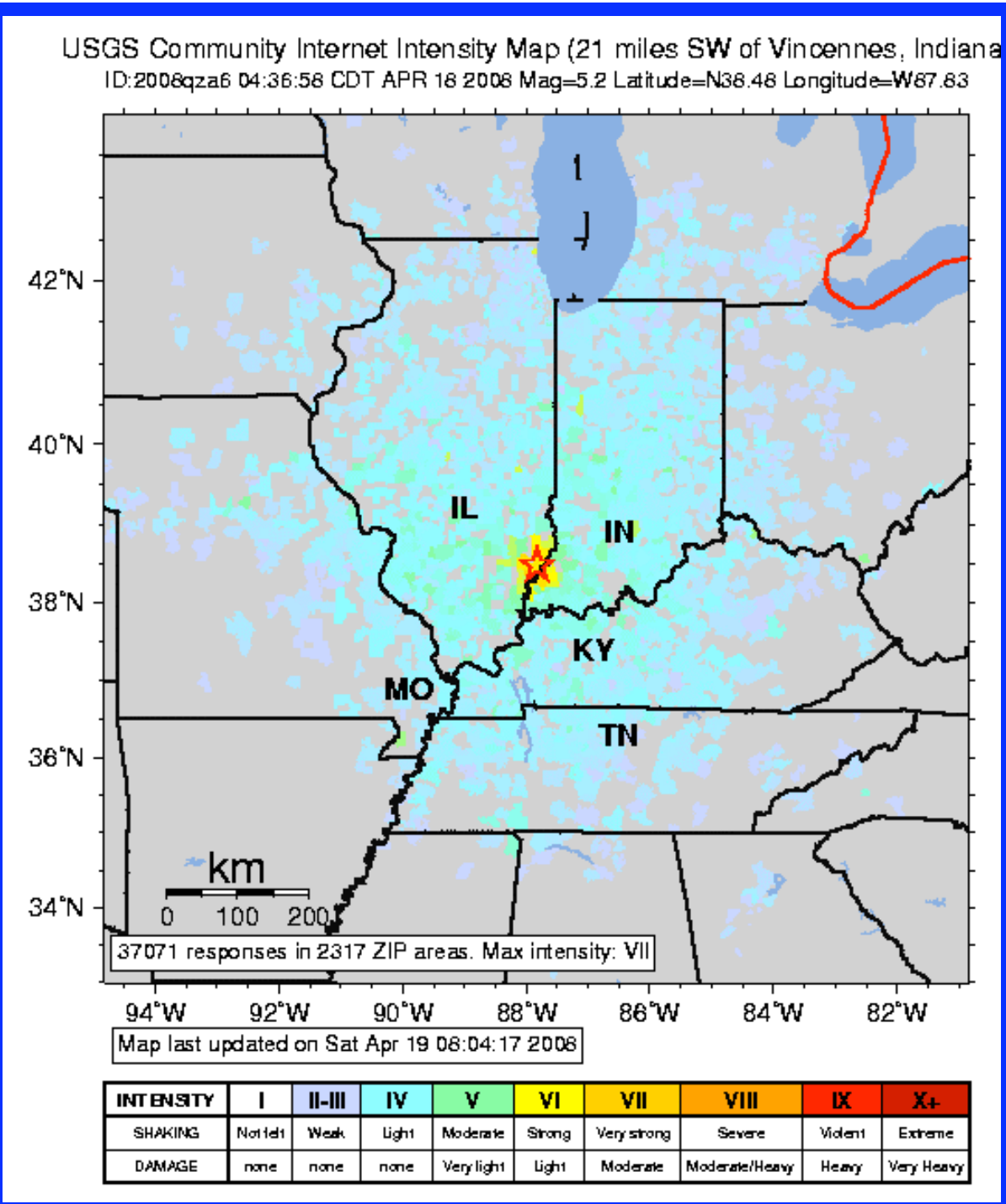
Describe the shaking you felt and its effects

Assign an intensity value and label it on the map

April 2008

M 5.2

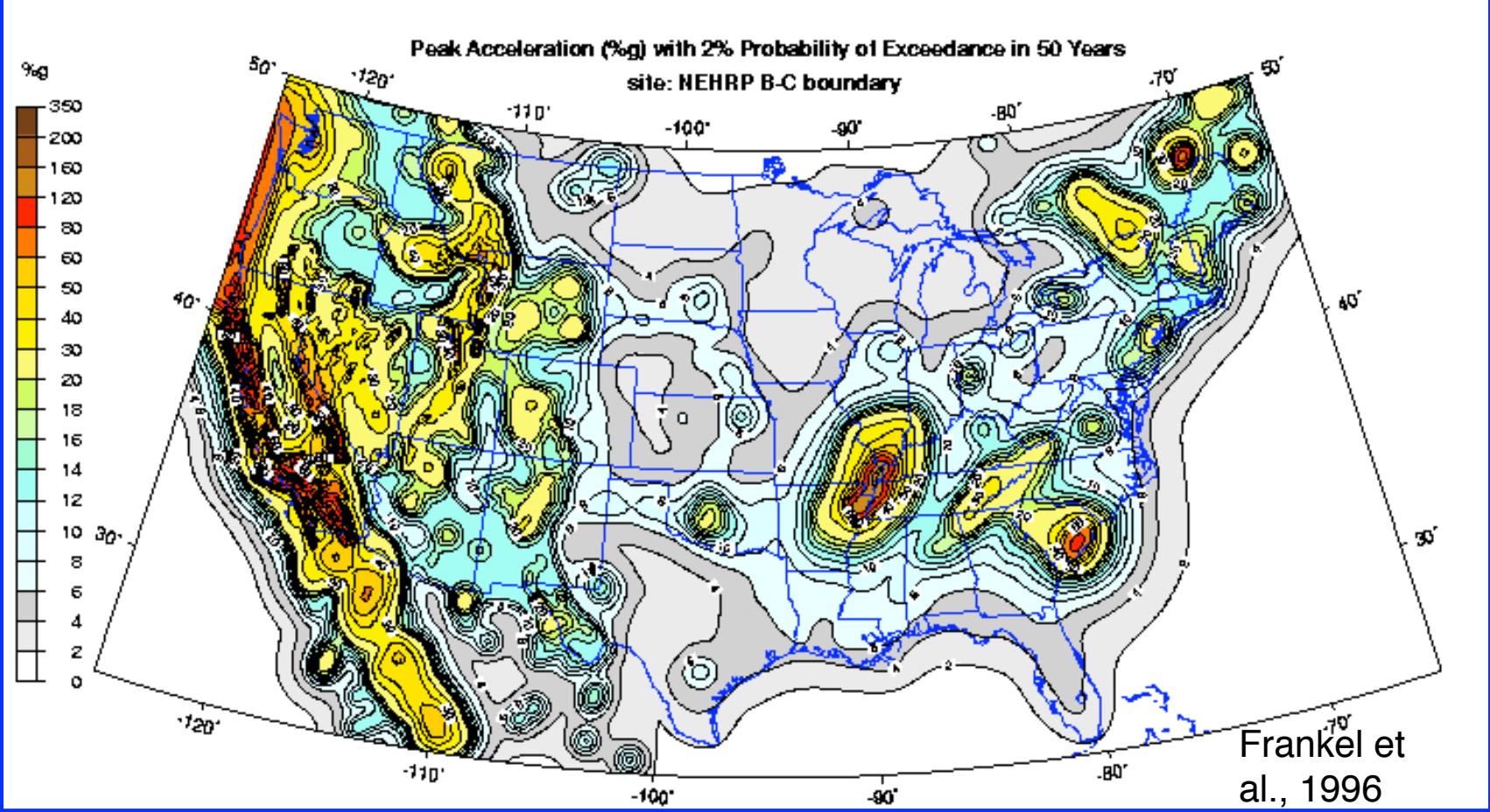
Intensity map



INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

USGS/FEMA claim: New Madrid as or more hazardous than California

Buildings should be built to same standards



Frankel et al., 1996

Given cost, important to decide if this makes sense