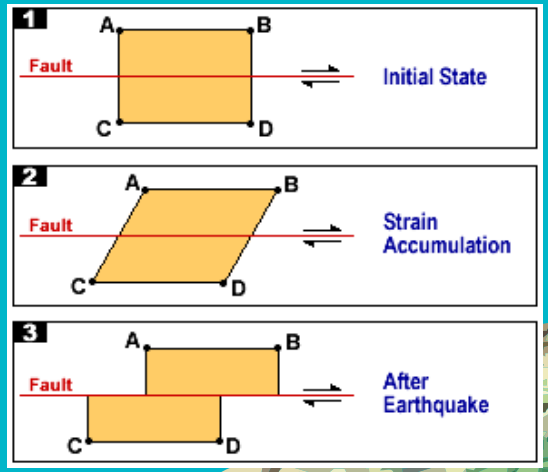
New Madrid Seismic Zone and Earthquake Hazards in the Central U.S.

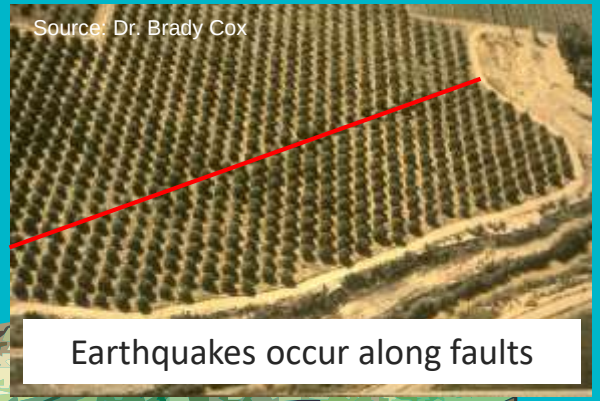
Earthquake Summit 2023

Arkansas Geological Survey
Scott M. Ausbrooks
Director and State Geologist
March 16, 2023

ARKANSAS
ENERGY & ENVIRONMENT

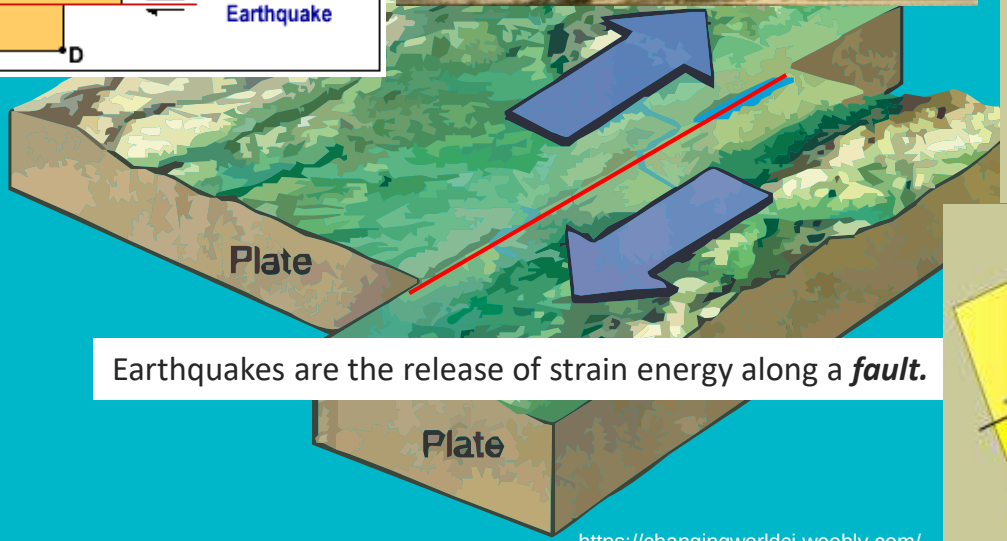
What causes an Earthquake?



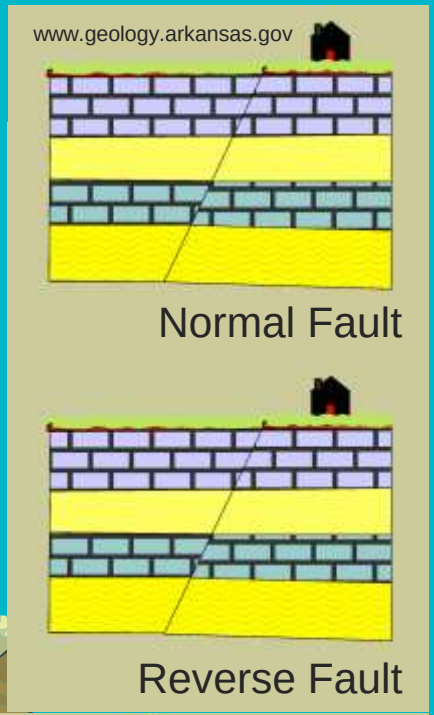


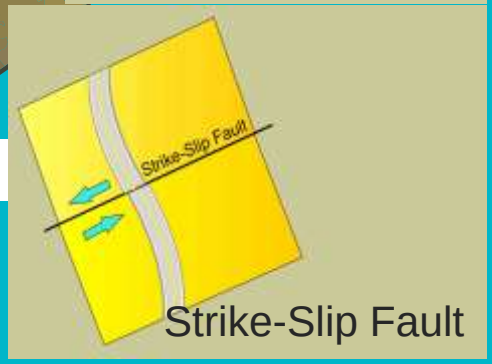
Earthquakes occur along faults

Fault – is a fracture within the Earth along which movement occurs.



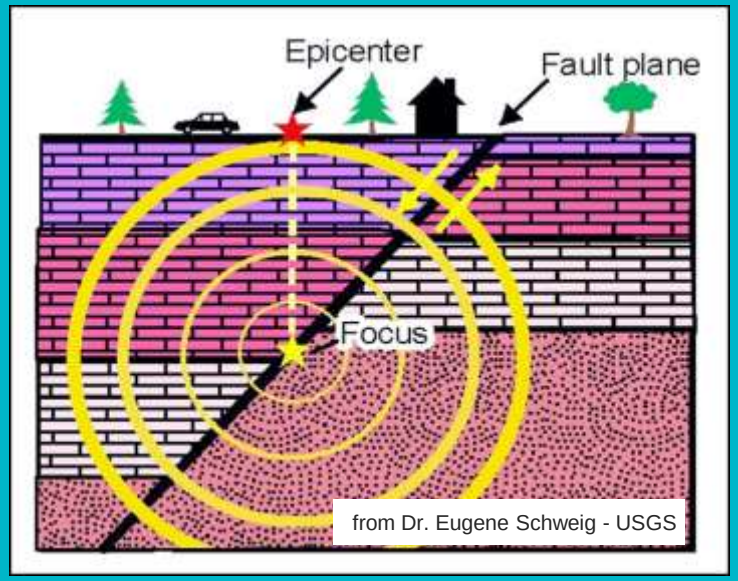
Earthquakes are the release of strain energy along a ***fault.***

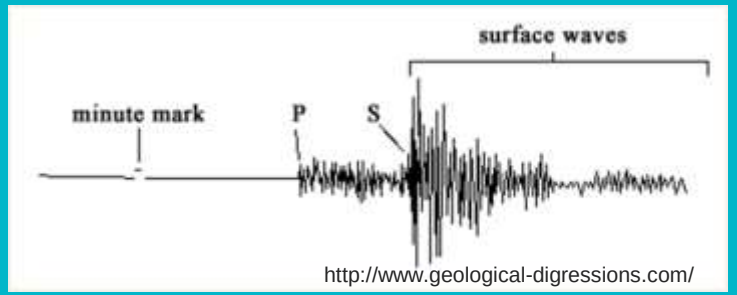


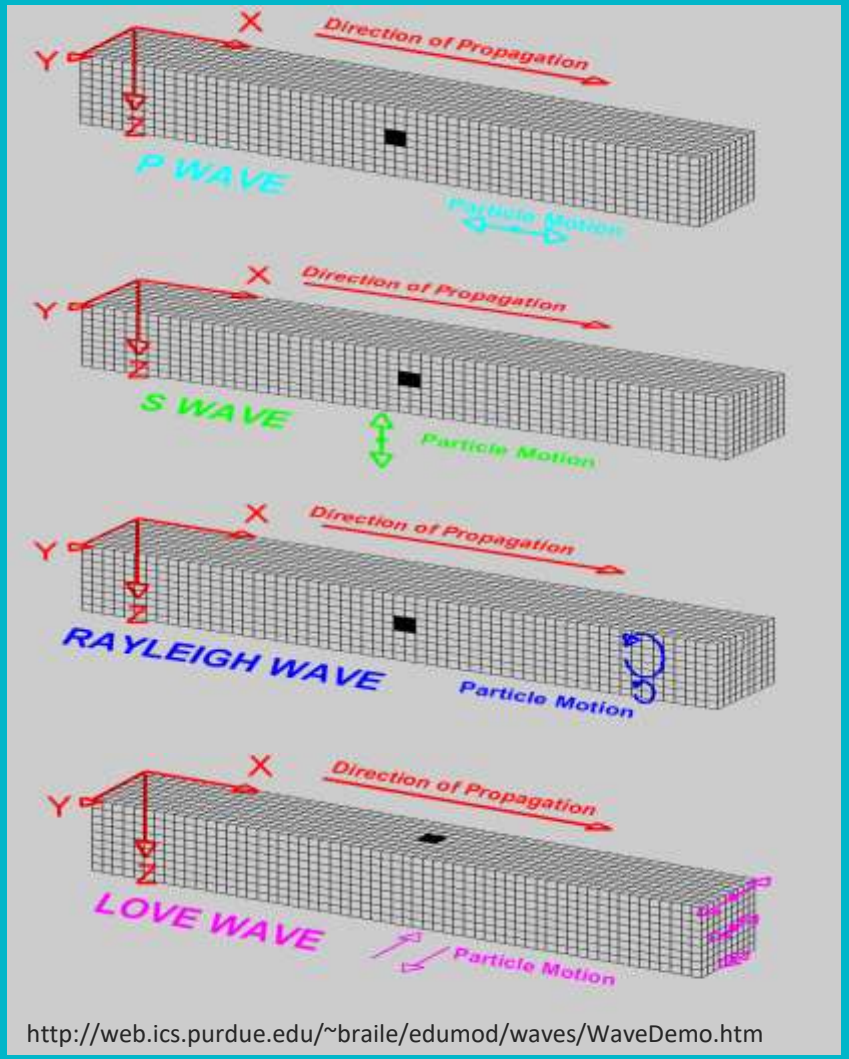


https://changingworldci.weebly.com/

Earthquake Basics







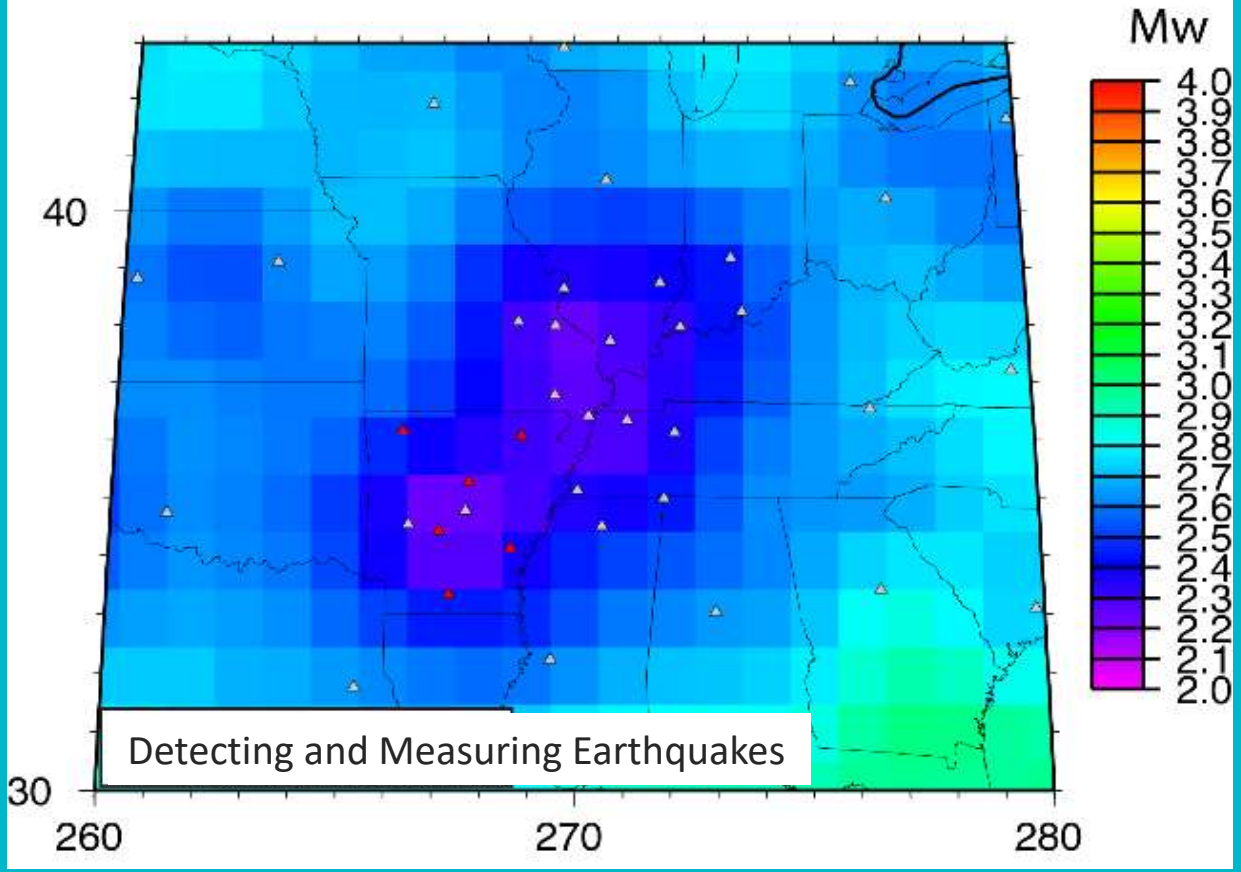
Temporary Seismic Station

Permanent Seismometer Vault and Equipment Enclosure

www.geology.arkansas.gov

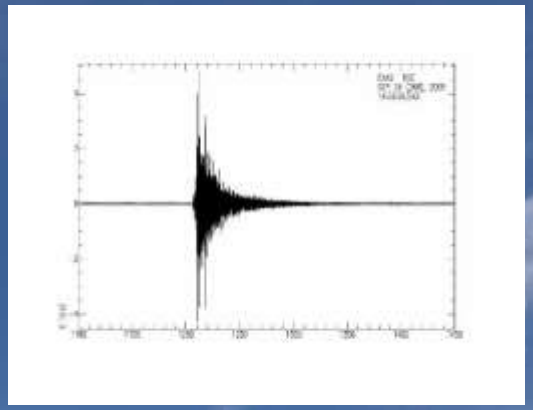
Magnitude Detection Threshold

Central U.S.



Detecting and Measuring Earthquakes

Arkansas Seismic Network Station Schematic



900 mHz
Radio Antenna

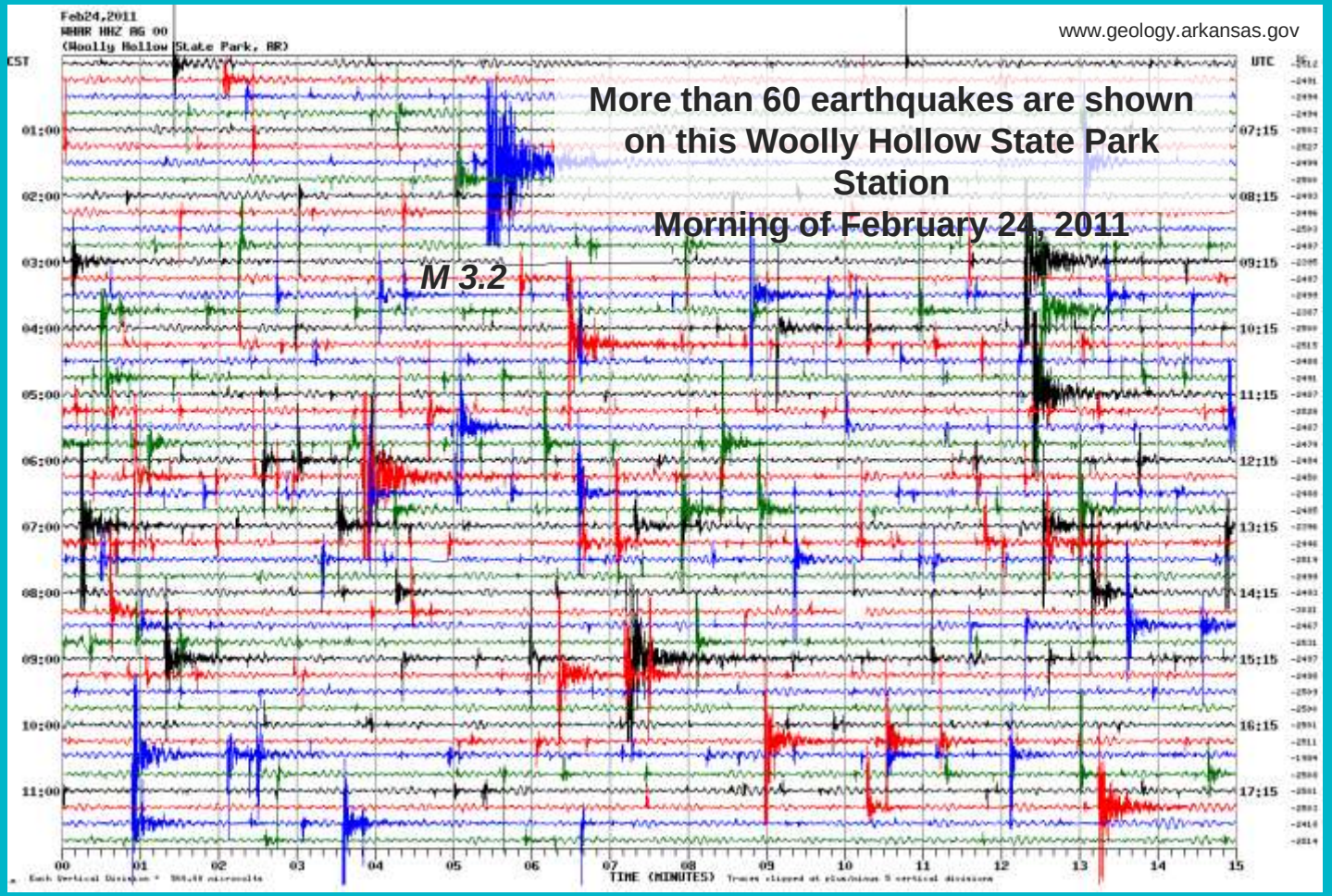
Solar Panels

Fiberglass Vault

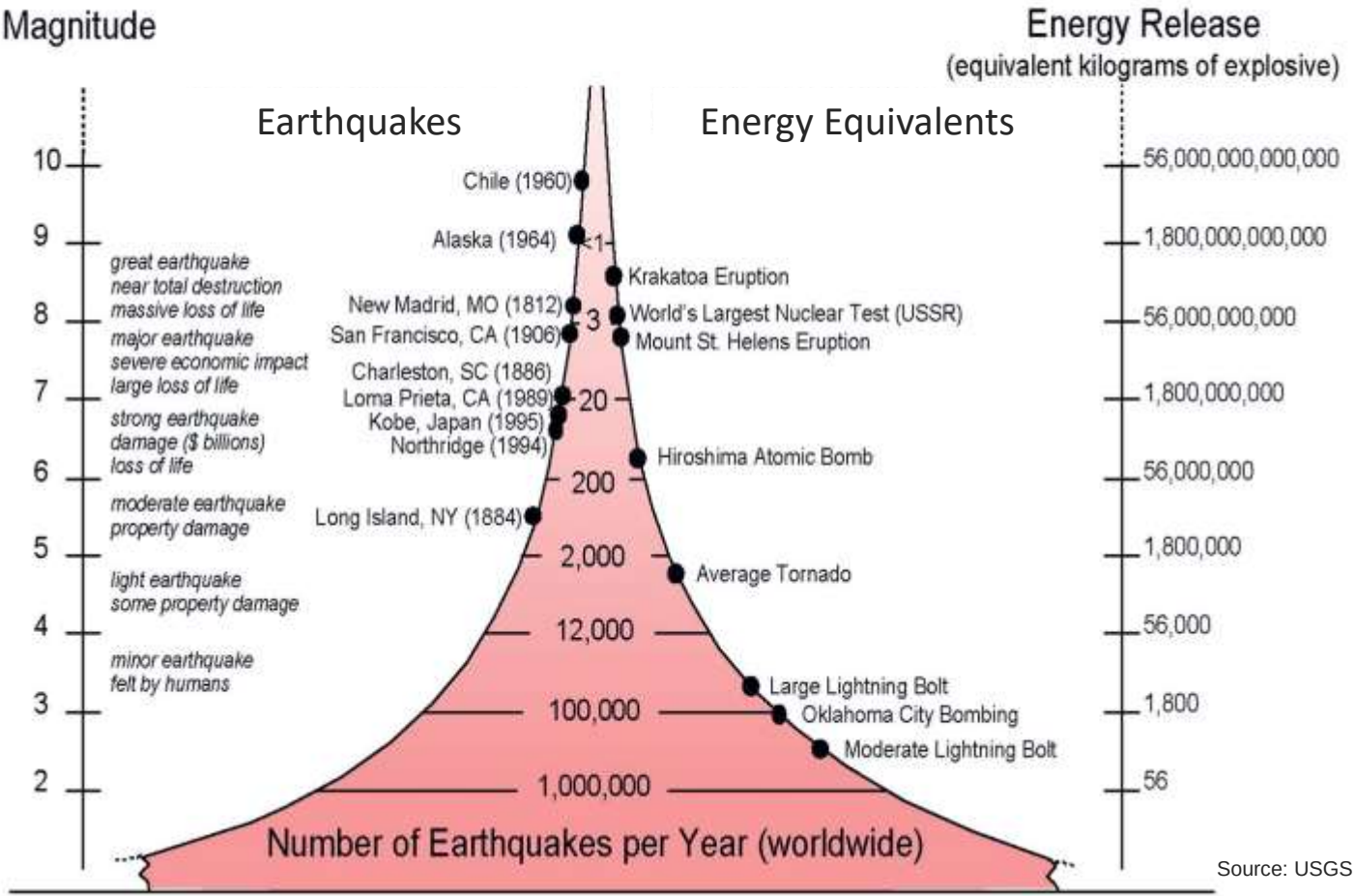
Seismometer

Equipment Box

Active Helicorder Display



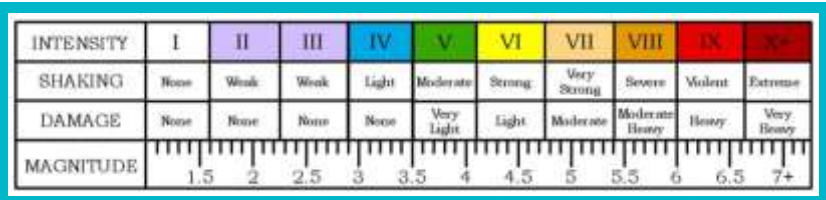
Magnitude = Energy Scale



Source: USGS

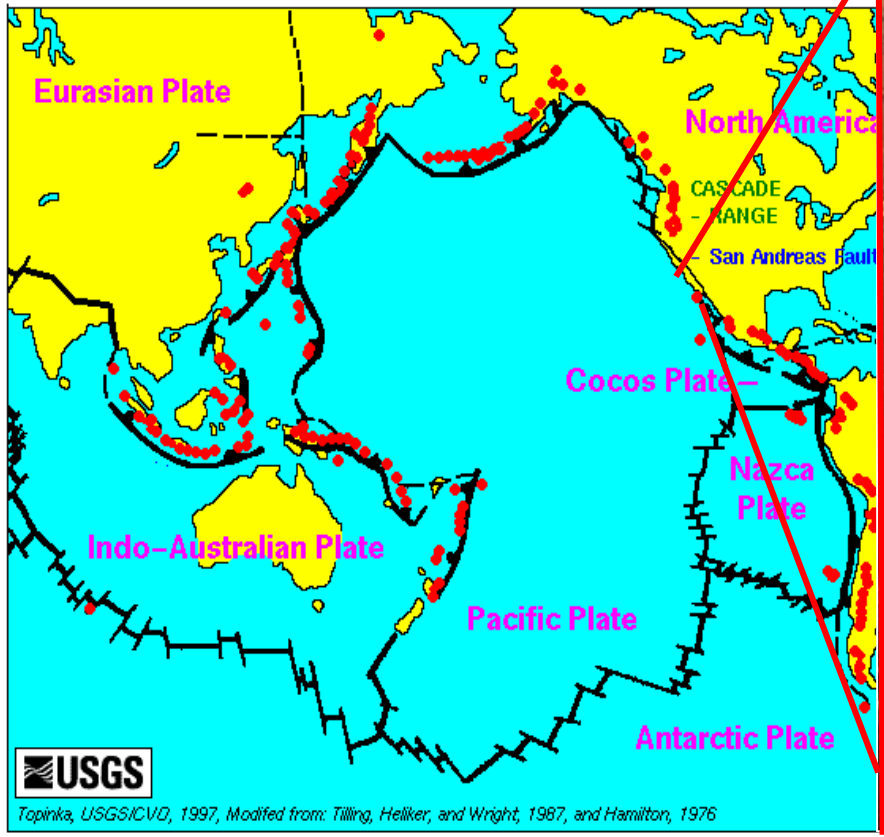
Intensity Scale

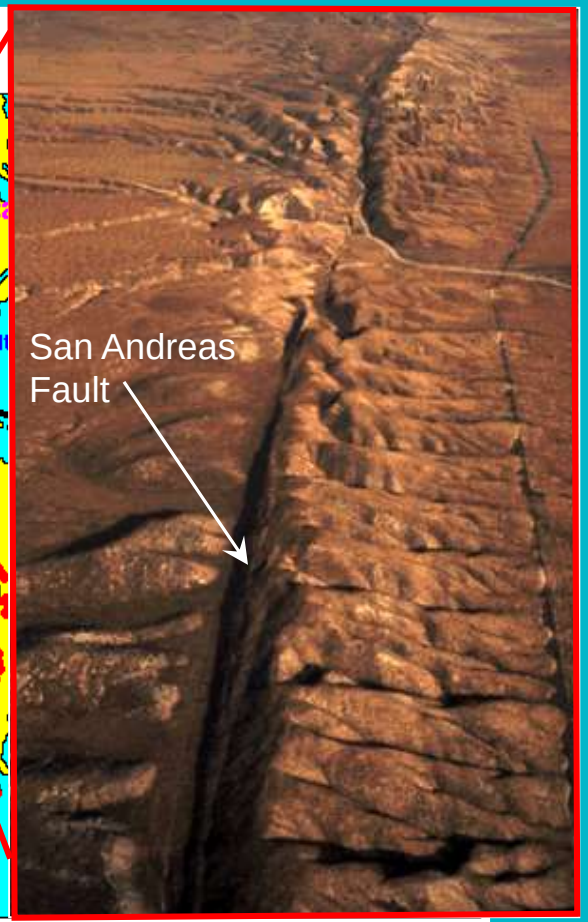
MMI Value	Perceived Shaking	Potential Damage	Full Description
I.	Not Felt	None	Not felt.
II.	Weak	None	Felt by persons at rest on upper floors.
III.	Weak	None	Felt indoors. Hanging objects swing. Vibration like passing of light trucks.
IV.	Light	None	Vibration like passing of heavy trucks. Parked vehicles rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. Wooden walls and frame creak.
V.	Moderate	Very Light	Felt outdoors. Sleepers wakened. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move.
VI.	Strong	Light	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Items fall off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry cracked. Trees shaken.
VII.	Very Strong	Moderate	Difficult to stand. Noticed by vehicle drivers. Furniture broken. Damage to masonry. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, etc. Waves on pond water. Small slides and caving in along sand or gravel banks. Large bells ring.
VIII.	Severe	Moderate/Heavy	Steering of vehicles affected. Damage to masonry. Fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations, if not bolted down. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground.
IX.	Violent	Heavy	Some masonry destroyed, heavily damaged, or collapsed. Damage to foundations. Frame structures shifted off foundations. Frames cracked. Reservoirs damaged. Underground pipes broken. Cracks in ground. In alluvial areas, sand and mud ejected, earthquake fountains, sand craters.
X.	Extreme	Very Heavy	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc.

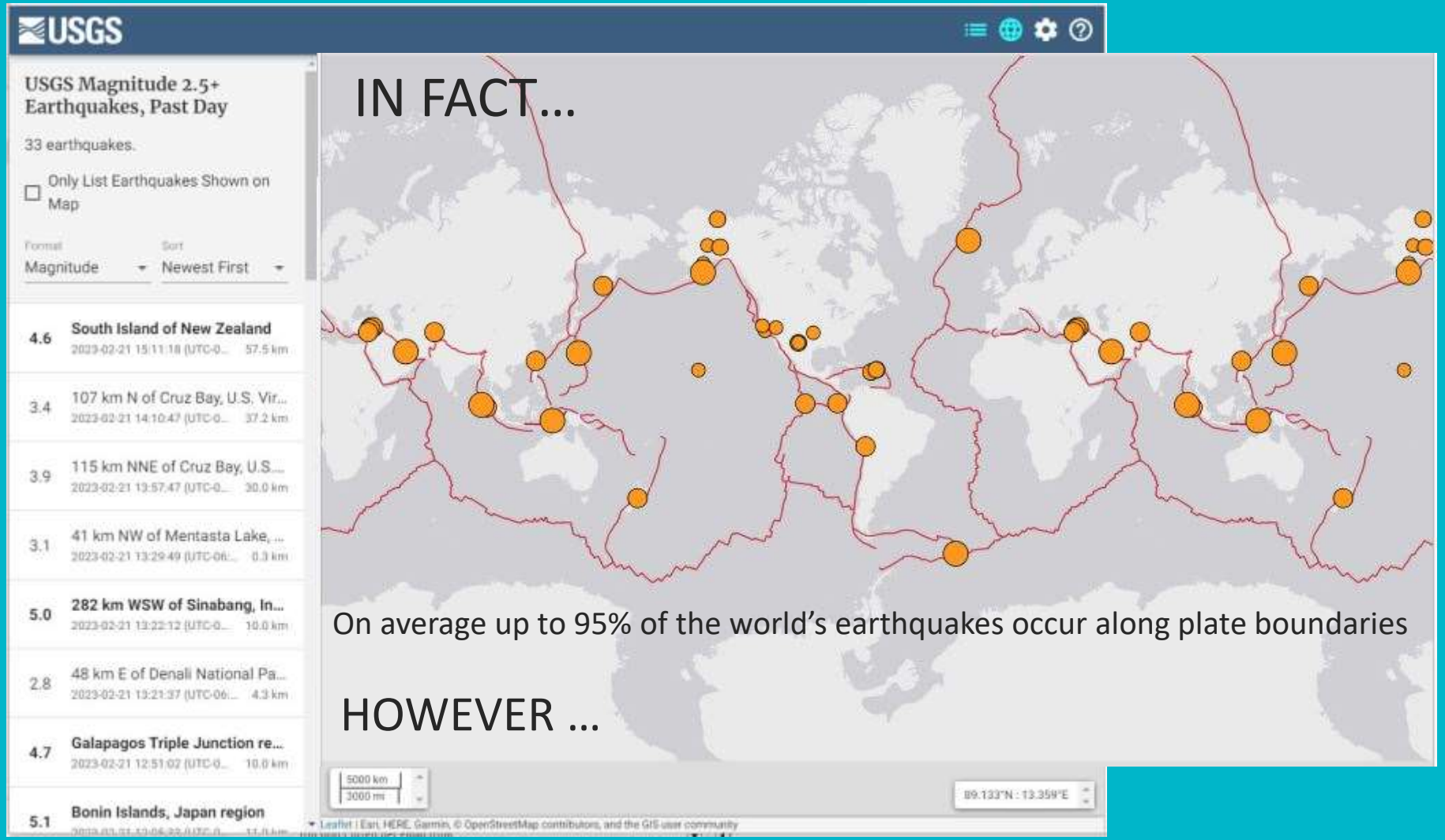


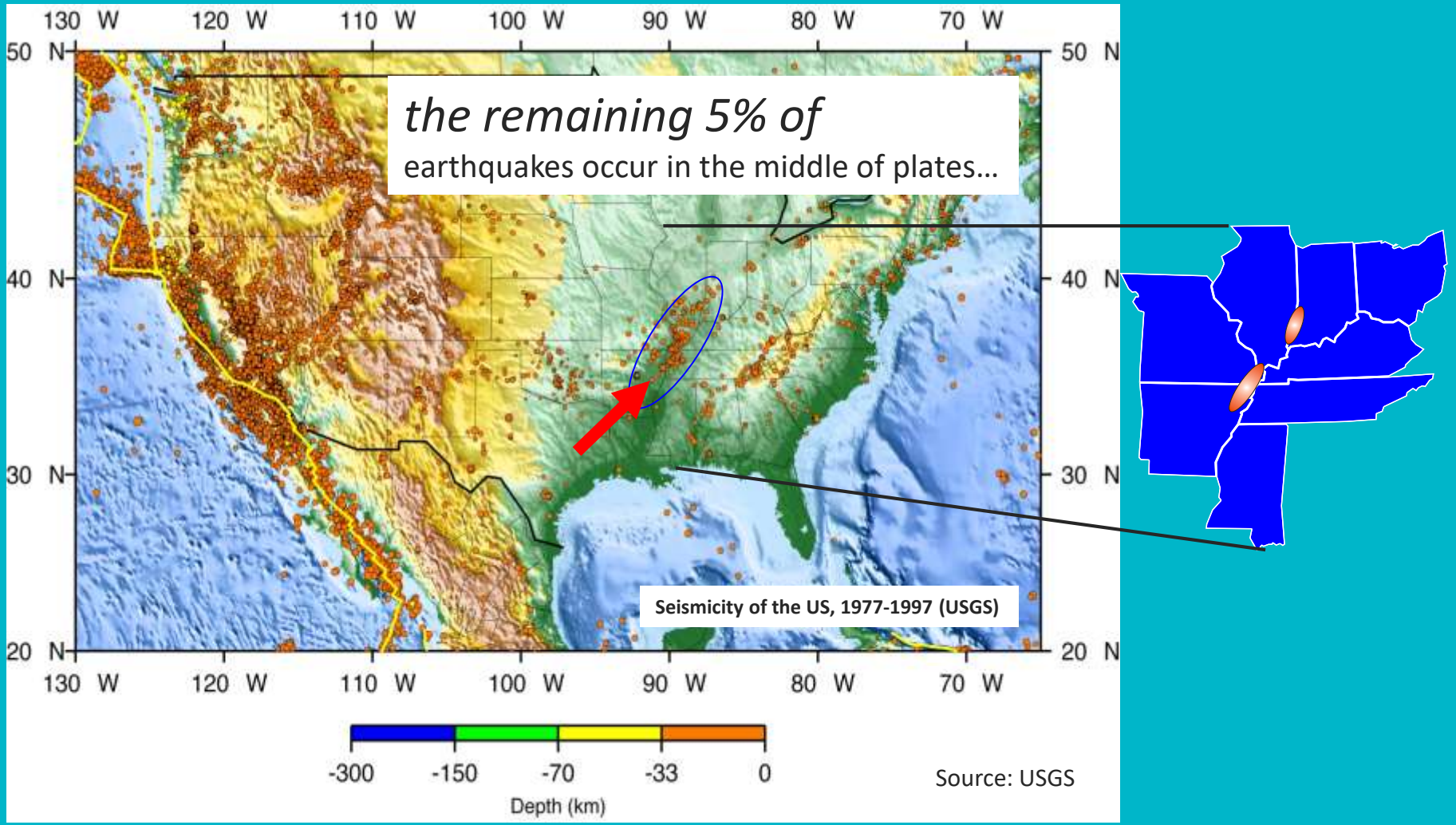
Where do earthquakes occur?

… along plate boundaries






USGS
USGS Magnitude 2.5+ Earthquakes, Past Day
33 earthquakes.
Only List Earthquakes Shown on Map
Format
Magnitude
Sort
Newest First
4.6 South Island of New Zealand
3.4 107 km N of Cruz Bay, U.S. Vir...
3.9 115 km NNE of Cruz Bay, U.S....
3.1 41 km NW of Mentasta Lake, ...
5.0 282 km WSW of Sinabang, In...
2.8 48 km E of Denali National Pa...
4.7 Galapagos Triple Junction re...
5.1 Bonin Islands, Japan region
IN FACT…
On average up to 95% of the world's earthquakes occur along plate boundaries
HOWEVER …
5000 km
3000 mi
89.133°N : 13.359°E
Leaflet | Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community



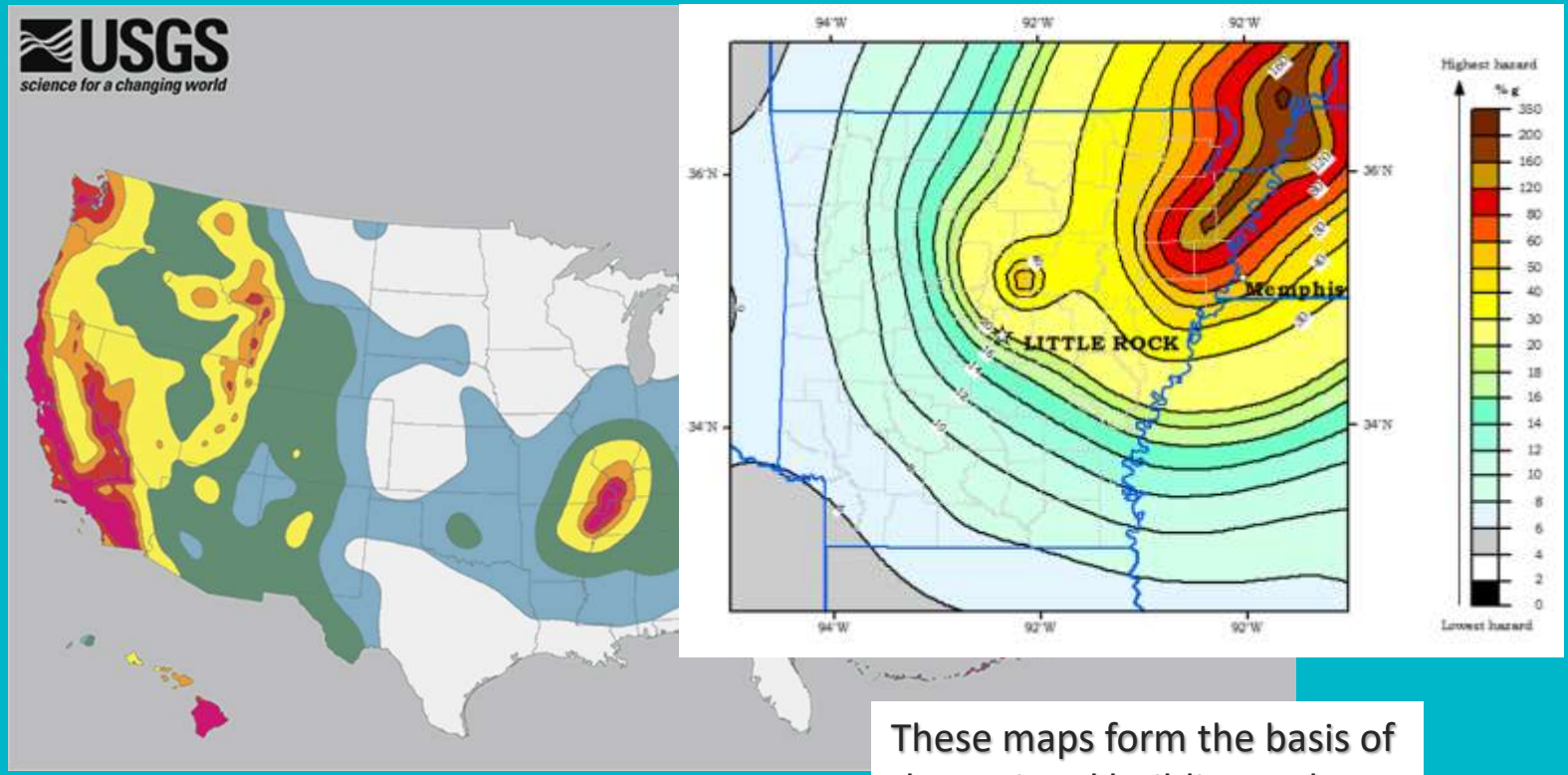
the remaining 5% of

earthquakes occur in the middle of plates…

Seismicity of the US, 1977-1997 (USGS)

Source: USGS

U.S. and Arkansas Seismic Hazard Maps*



NMSZ - one of the most hazardous earthquake areas in the U.S.

These maps form the basis of the national building codes…

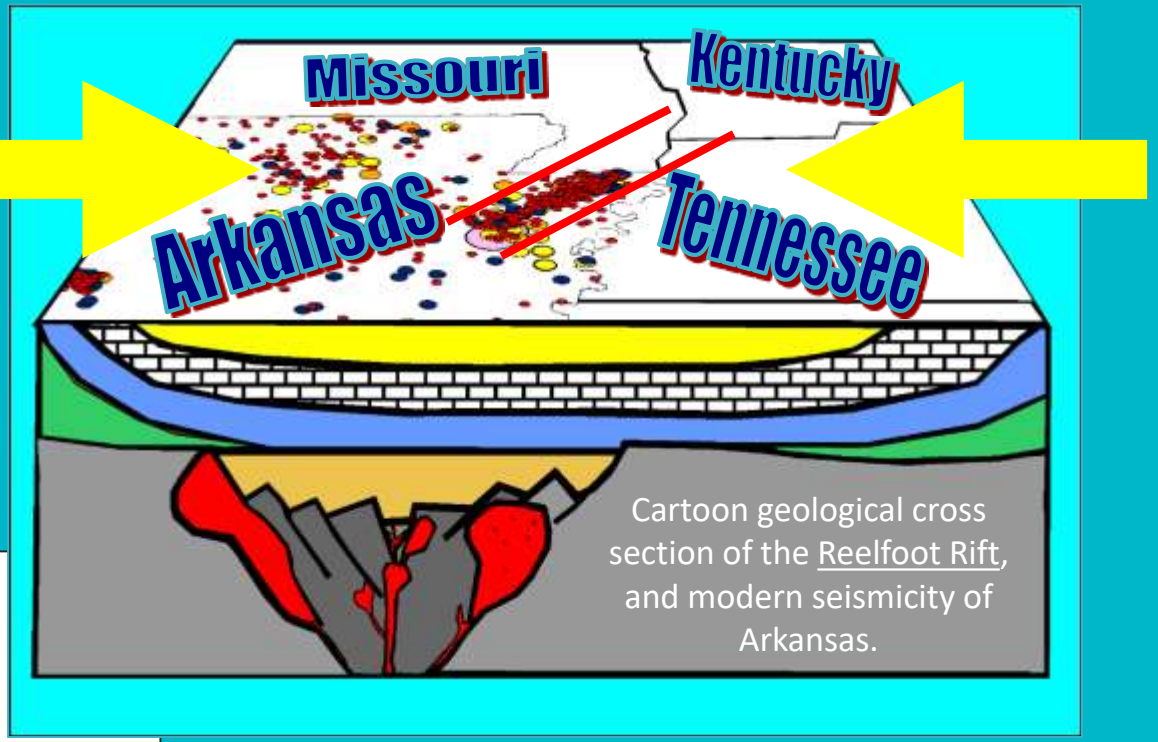
*Source: USGS: %g is the acceleration of a falling object due to Earth's gravity (32.09 ft./s)

The Reelfoot Rift

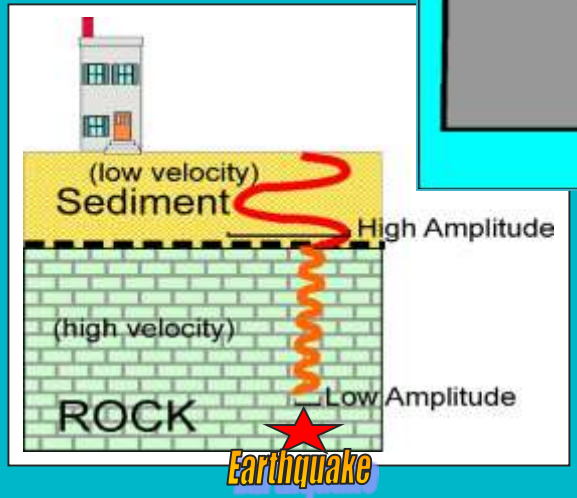
Over 600 million years ago, a rifting event took place…

The rift failed, but it resulted in the weakening of the continental crust.

The New Madrid fault system lies within confines of the ancient rift structures now being acted on by compressional forces.



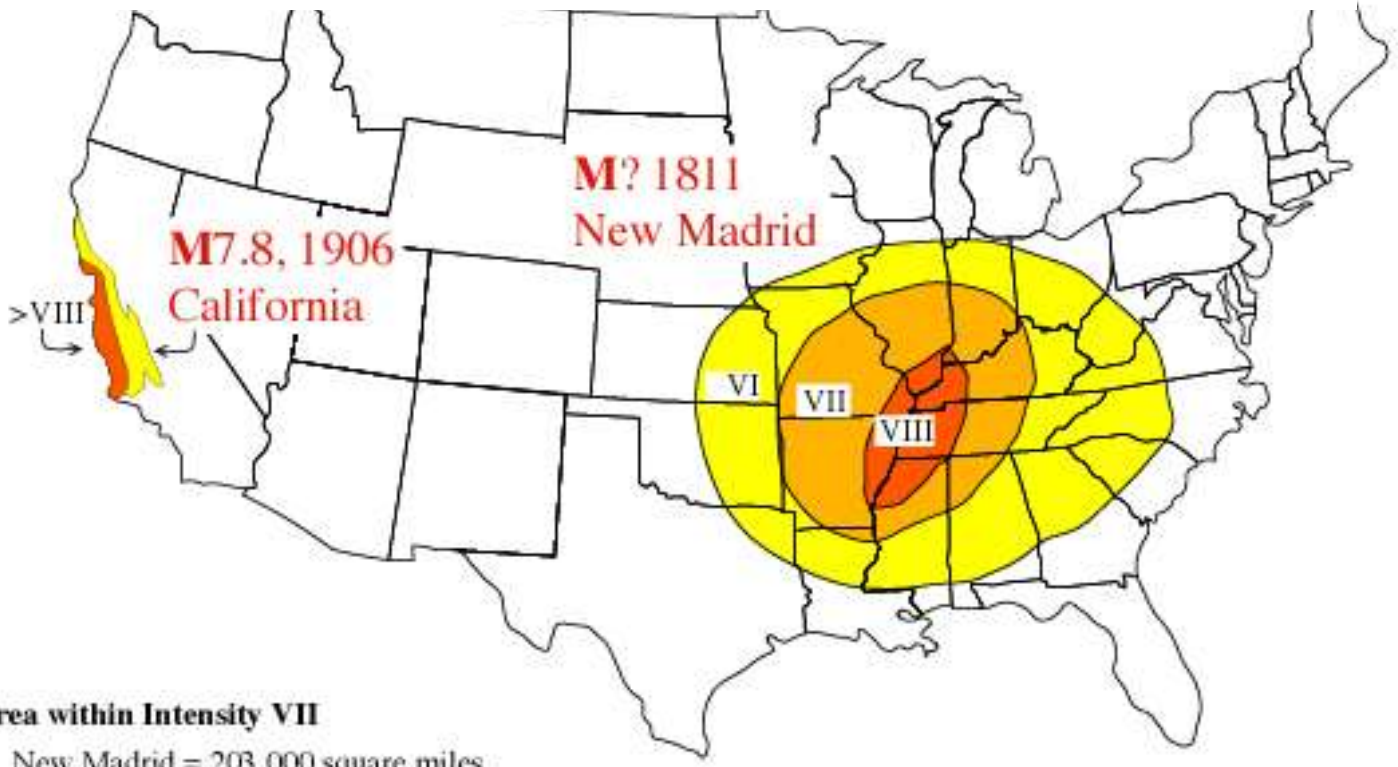
Cartoon geological cross section of the Reelfoot Rift, and modern seismicity of Arkansas.



Regional geology can affect the attenuation of seismic energy.

Local site conditions can amplify seismic energy from earthquakes.

Impacts of earthquakes felt over much larger area in Central United States



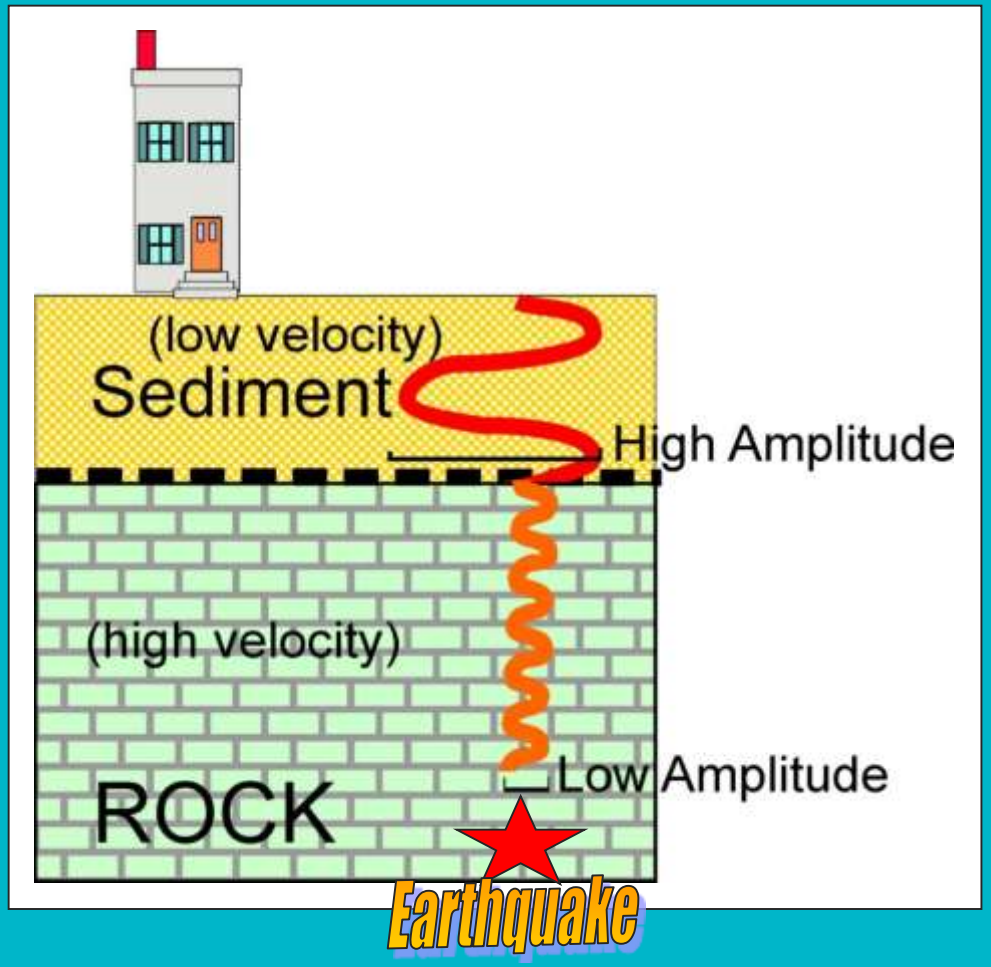
Area within Intensity VII

New Madrid = 203,000 square miles

San Francisco = only 12,000 square miles!

An earthquake east of the Rocky Mountains can be felt over an area as much as ***ten times*** larger than a similar magnitude earthquake on the west coast.

from Dr. Eugene Schweig - USGS



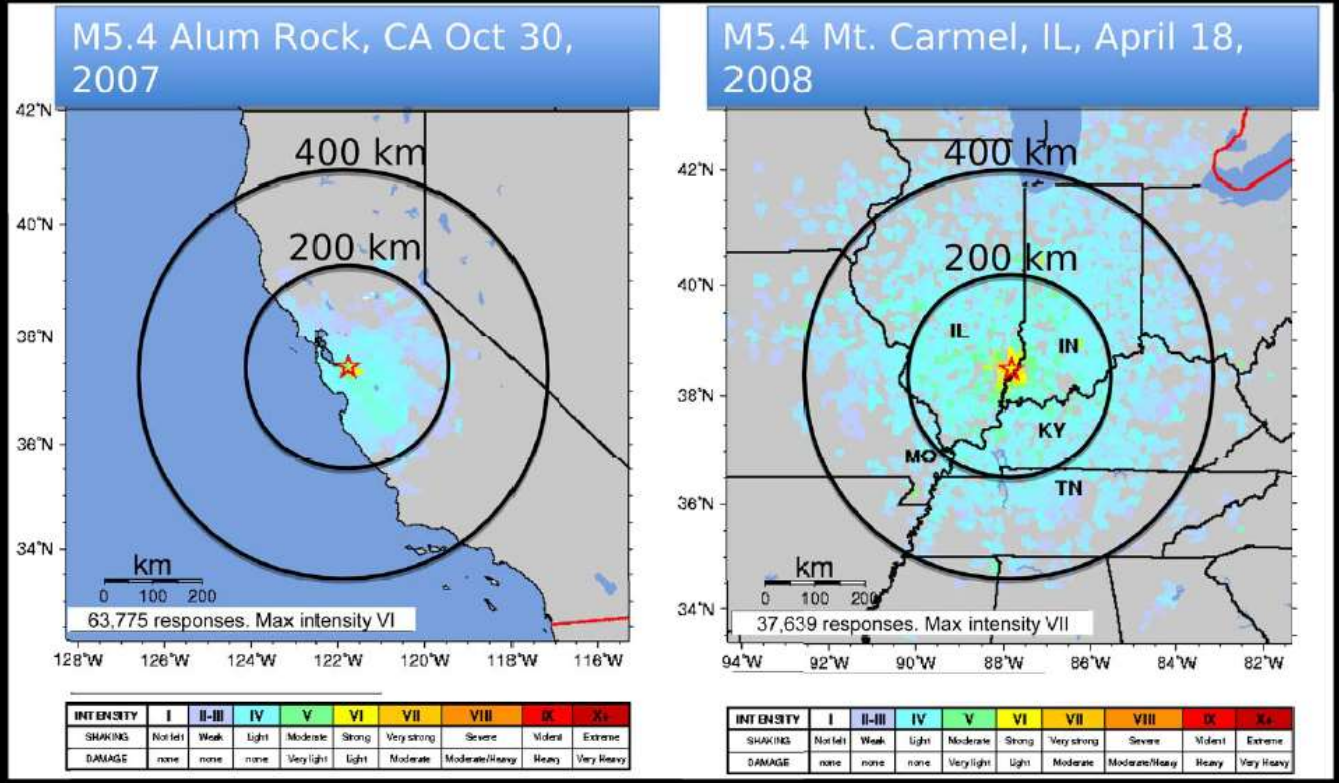
Soil Amplification

Seismic waves can amplify as they pass from consolidated rock into unconsolidated sediment.

This can make increase the amount of shaking during an earthquake.

Felt Area is Much Larger in the Eastern U.S. than in California

"Did You Feel It" Earthquake Intensity Comparison



USGS

"Did you feel it?" - http://pasadena.wr.usgs.gov/shake/ca/

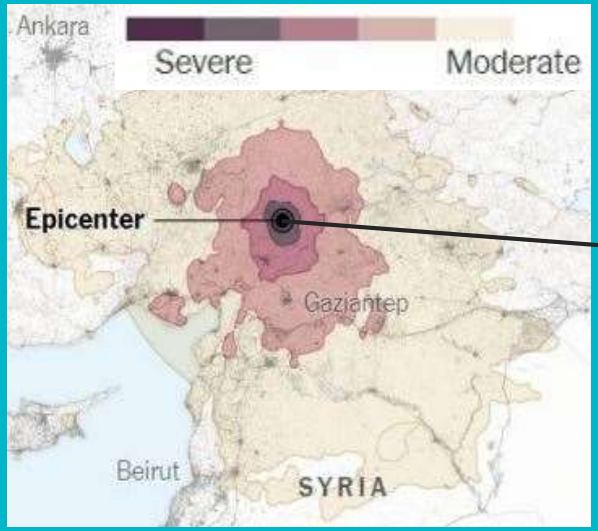
Figure courtesy of Dave Wald, USGS

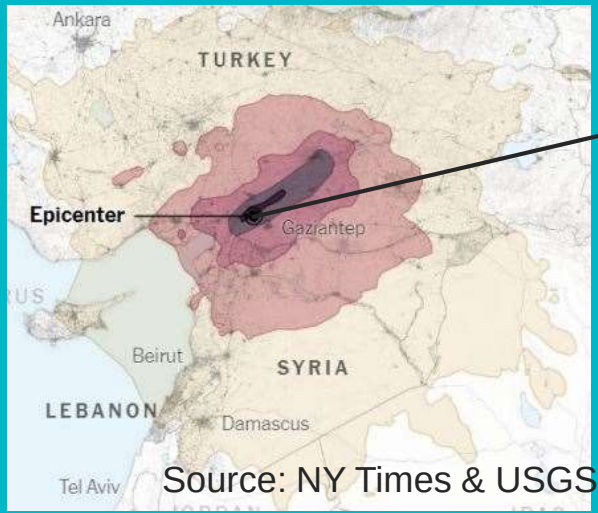
Earthquake-related Geohazards

- Strong shaking & aftershocks
- Landslides (slope movement)
- Land subsidence/inundation/flooding
- Liquefaction
- Lateral spreading

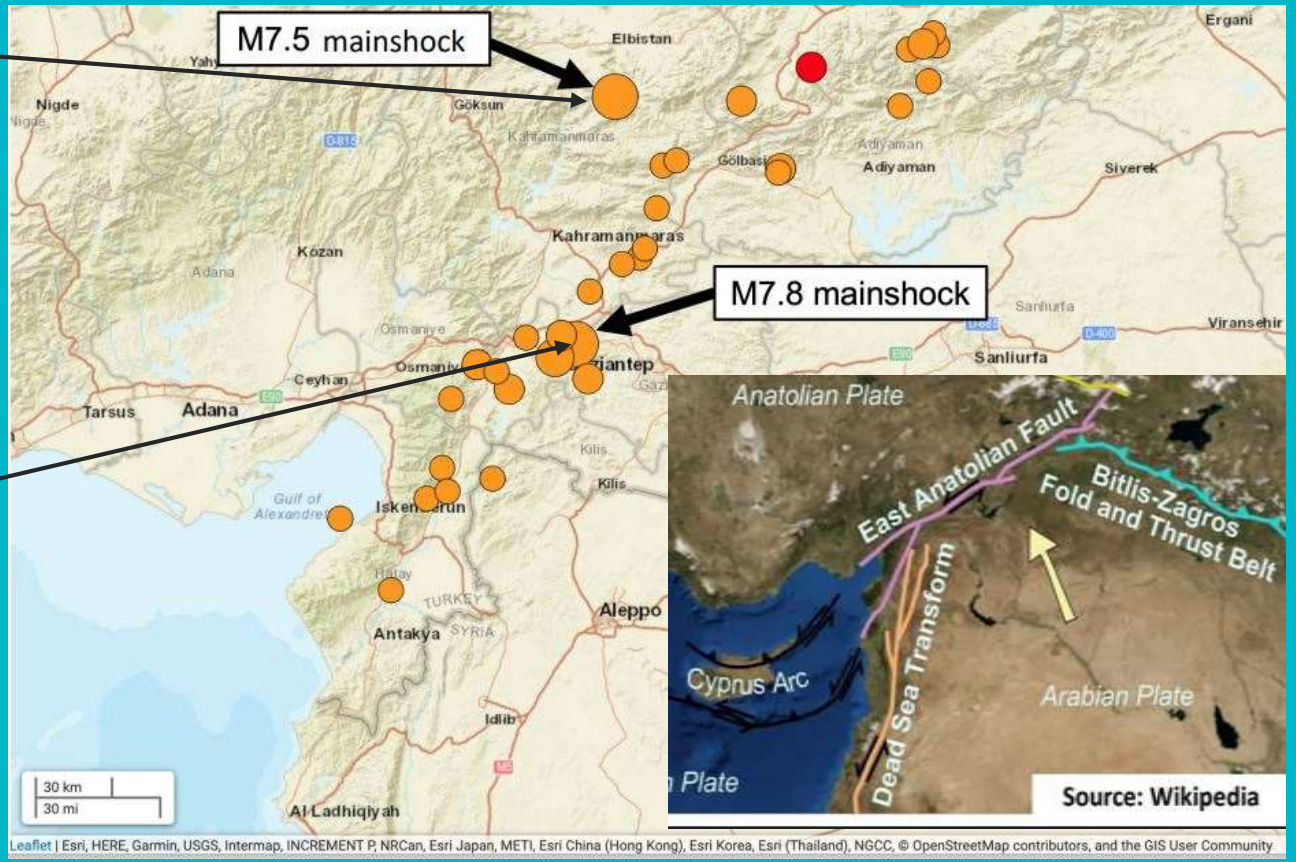
A magnitude 7.8 strike slip earthquake is associated with a rectangular fault rupture of ~240 km long and ~20 km wide. Nine hours after the first earthquake of M 7.8 a second earthquake of M 7.5 occurred 100 km to the north

Source: EERI – GARINI and GAZETAS





Source: NY Times & USGS



SUMMARY of Structural Damage in Turkey

- Tens of Thousands killed **(~50,000)** and numerous more **(~100,000)** injured.
- In total, around nearly **5000 buildings collapsed** in ten provinces across Turkey.
- Many buildings were destroyed in Adıyaman and Diyarbakır. In Diyarbakır, a **shopping mall collapsed**.
- Approximately **130 building collapses** also occurred in Malatya.
- Kahramanmaras, a city of more than **1 million people**, has been hit hard, as have Malatya, Hatay, and other regions and reports suggest up to **10 major cities heavily affected by collapsing buildings**.
- In Adana, apartment buildings, one of them **17 stories high, collapsed, killing >> at least ten people**.
- In Hatay Province, the runway of **Hatay Airport was split and uplifted**.
- Two provincial **hospitals** and a **police station** were **destroyed**, and a **gas pipeline exploded**.

SUMMARY of Structural Damage in Syria:

- Several thousands **(~5,000)** were killed and numerous more injured.
- **Collapses** occurred in the cities of Aleppo, Latakia, and Hama.
- In Damascus, many **people fled from their homes** onto the streets.

Source: EERI – GARINI and GAZETAS

Location: Şakirpaşa, Turkey
Distance to epicenter:
161.2 Km

Flattened buildings in Hatay, Turkey

Credit: Anadolu Agency, Erçin Ertürk

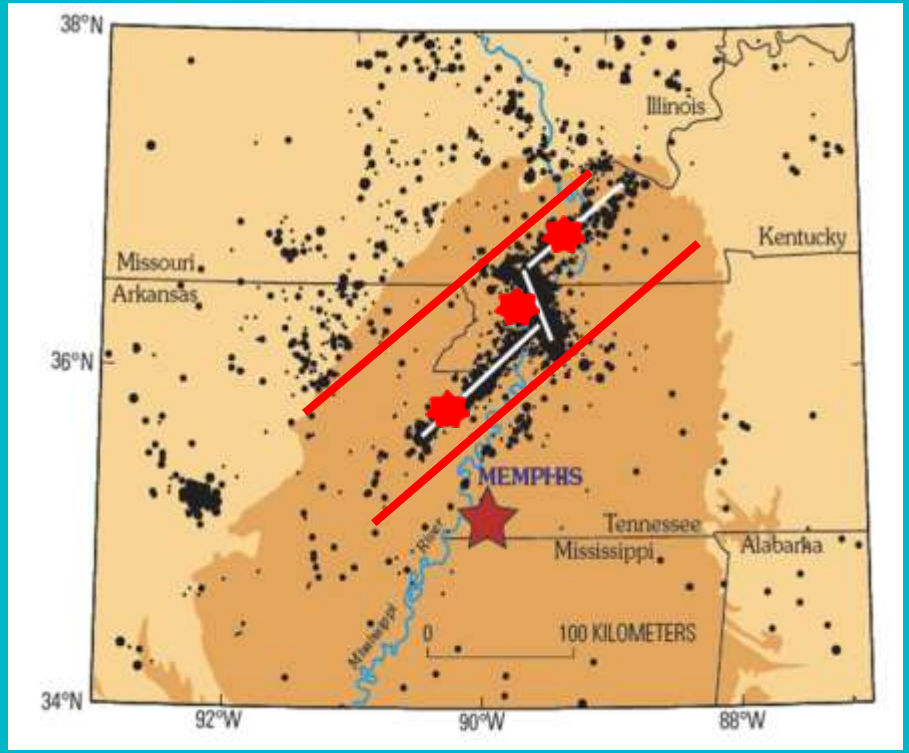
Damage to runway at Hatay Airport

A collapsed building in Hatay, Turkey, February 7, 2023.

(Photo: REUTERS/ Umit Bektas/ File Photo)

NMSZ and the1811-1812 Earthquakes

Most seismically active area east of the Rocky Mountains



Largest NMSZ Earthquakes:

December 16, 1811 @ 2:15 AM ~ M7.4 – 7.8
January 23, 1812 @ 9:00 AM ~ M7.4 – 7.8
February 7, 1812 @ 3:45 AM ~ M7.6 – 8.0

Source: USGS

NMSZ Facts:

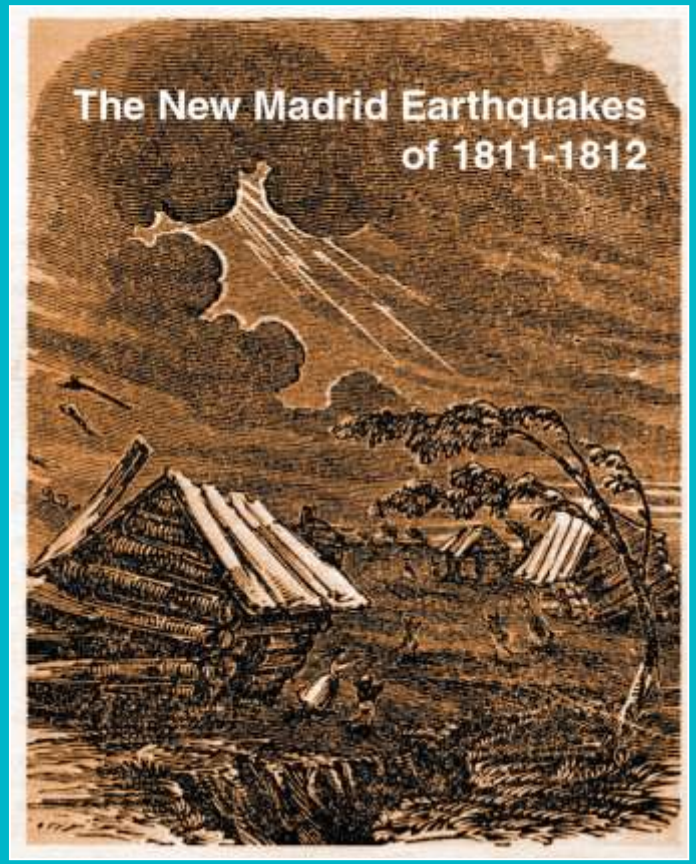
Earthquakes occur along the NMSZ nearly every other day. Approximately 200 earthquakes per year occur.

Over 20 damaging earthquakes have occurred since the events of 1812.

Large earthquakes have also occurred in 900 A.D. and 1450 A.D.

The NMSZ is still capable of producing major earthquakes

Effects of the 1811-1812 Earthquakes



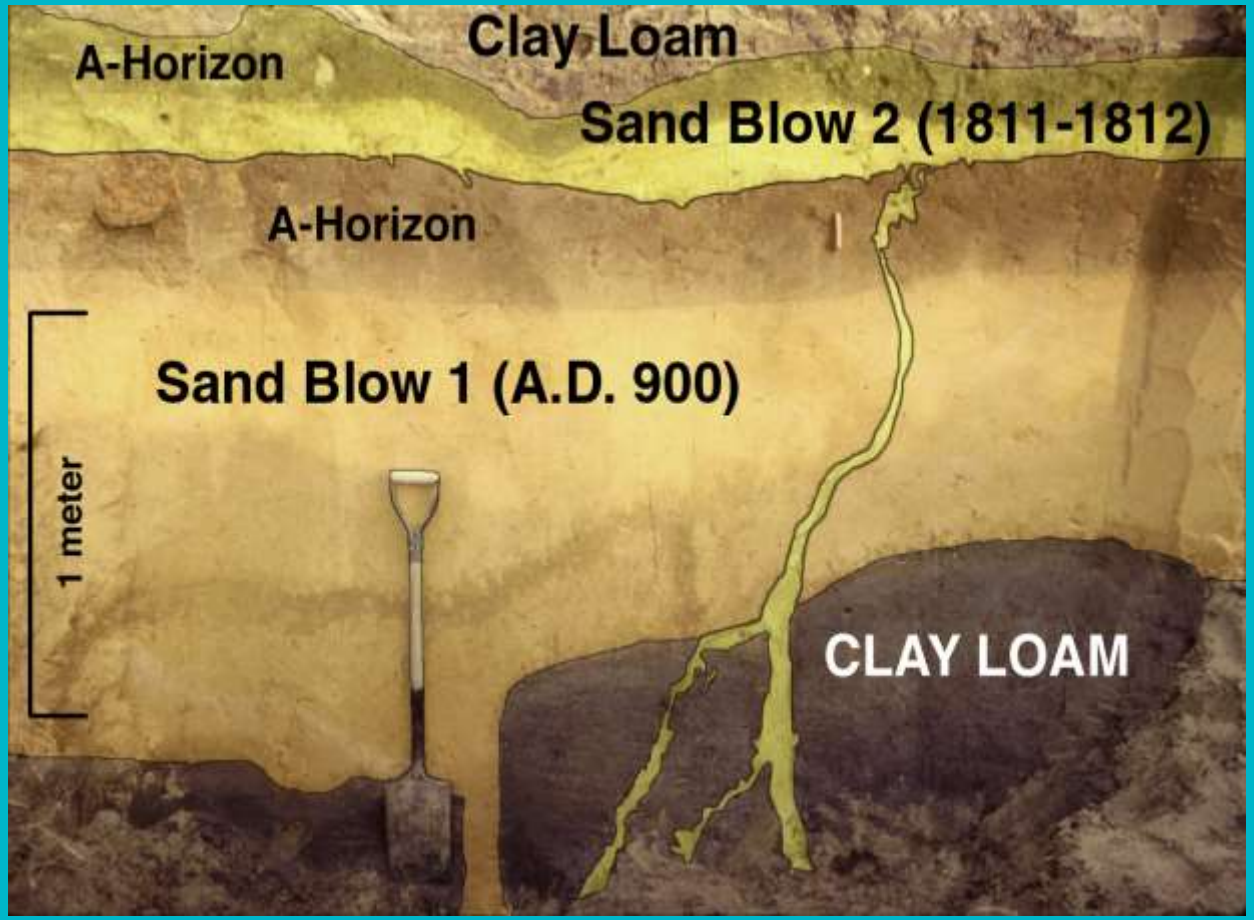
Widespread liquefaction, including fissuring and sand/water fountaining.

Creation of sunken land lakes, primarily Reelfoot in Tennessee; also St. Francis and Big Lake in Arkansas.

"Sunken" forests and “uplifted” lowlands.

Waterfalls, rapids and barriers on the Mississippi River.

Research on the NMSZ utilizing Paleo-seismology tells us:



Large earthquakes in 1450 and 900 A.D.

The average time between the large earthquakes is about 500 years

The prehistoric earthquakes were approximately the same size as the 1811-1812 earthquakes

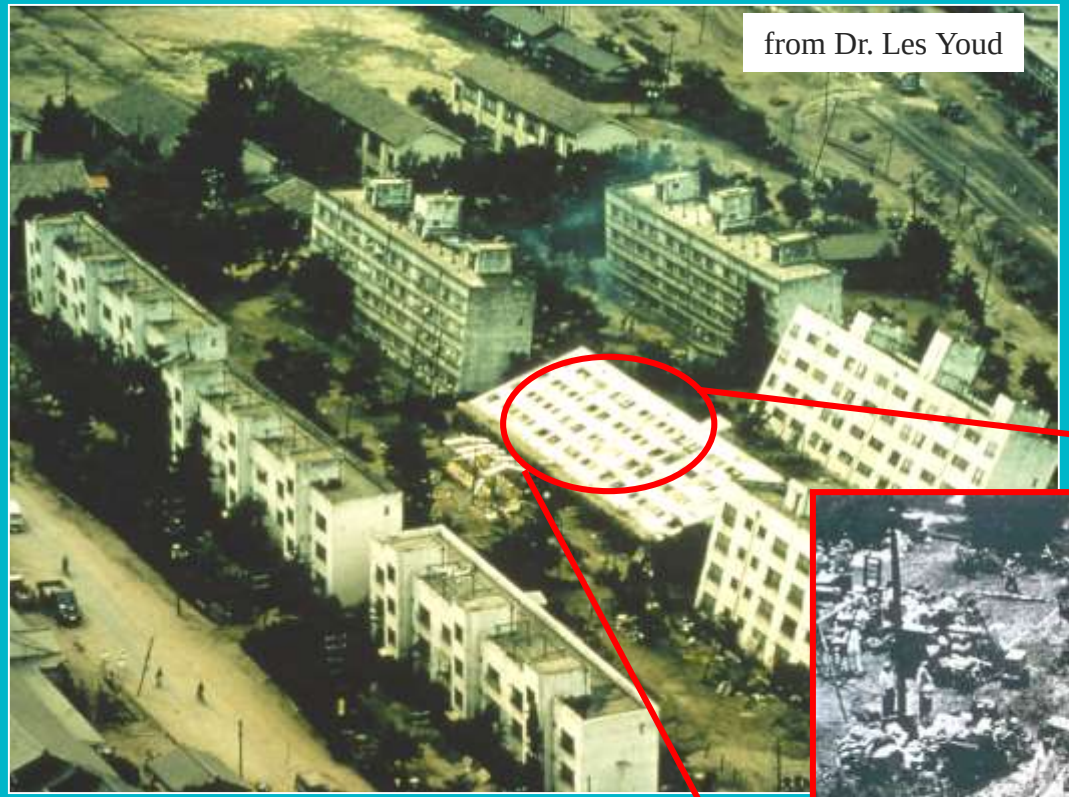
Each may actually represent sequences of large earthquakes, as in 1811-1812

Liquefaction

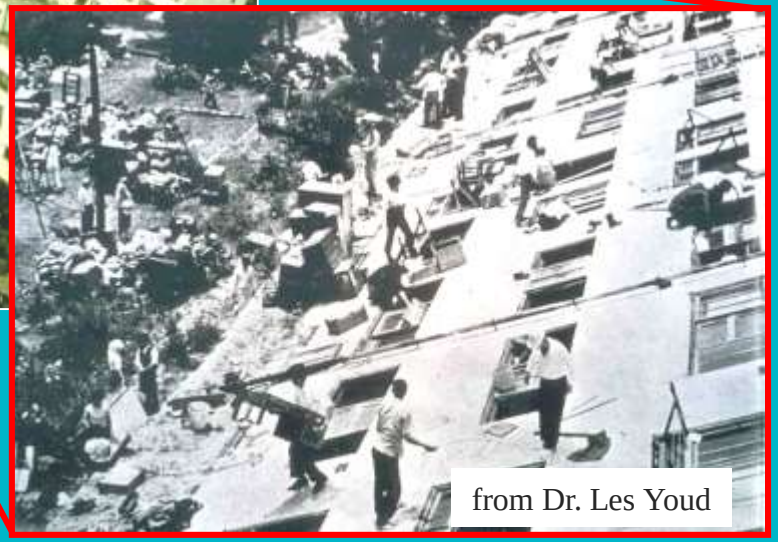
During strong ground shaking, pore water pressure in saturated, loose sand increases until the sand loses its shear strength and acts like a liquid, finally erupting to the ground surface through fissures, forming sand blows.

Liquefaction-Induced Bridge Failures

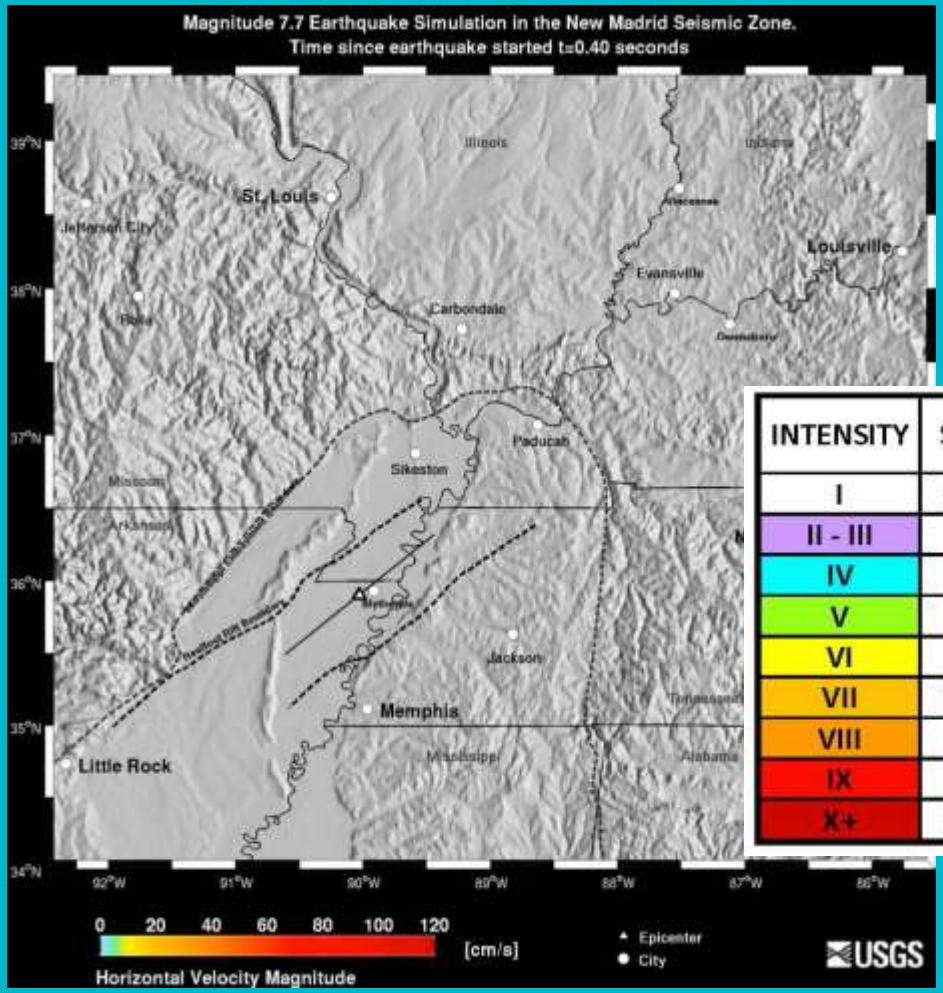
"Liquefaction of saturated granular foundation soils has been a major source of bridge failures during historic earthquakes." AASHTO LRFD Code



1964 Niigata, Japan EQ: M7.5



Liquefaction-Induced Bearing Capacity Failures



M7.7 NMSZ Earthquake Simulation

INTENSITY	SHAKING	DAMAGE	PEAK ACC (g)	PEAK VEL (cm/s)
I	Not Felt	None	<0.17	<0.1
II - III	Weak	None	0.17 - 1.4	0.1 - 1.1
IV	Light	None	1.4 - 3.9	1.1 - 3.4
V	Mod	V Slight	3.9 - 9.2	3.4 - 8.1
VI	Strong	Light	9.2 - 18	8.1 - 16
VII	V Strong	Mod	18 - 34	16 - 31
VIII	Severe	Mod/Hvy	34 - 65	31 - 60
IX	Violent	Heavy	65 - 124	60 - 116
X+	Extreme	V Heavy	> 124	> 116

Intensity Scale

New Madrid Seismic Zone (NMSZ)

- The NMSZ has a **7 to 10%** chance of producing a **M7.0** or greater earthquake within a **50-year period**

  and

- a **25 to 40%** chance of producing a **M6.0** or less earthquake within a **50-year period**

FEMA Hazus software run (HAZUS MR3; FEMA and MAEviz) on the NMSZ showed:

- Significant damage to property approaching ***$300 billion*** direct economic losses
- Nearly ***86,000 CEUS injuries and fatalities*** resulting from damage to infrastructure…

Reference: Mid America Earthquake Center, Final Report for SG-4 Characterization of Active Faults in the New Madrid Seismic Zone, R. Van Arsdale and Michael Ellis

USGS Earthquake Information Products

M 7.8 – 26 km ENE of Nurdağı, Turkey

2023-02-06 01:17:34 (UTC) | 37.225°N 37.021°E | 10.0 km depth

Interactive Map

Contributed by US [2]

Regional Information

Contributed by US [2]

Felt Report - Tell Us!

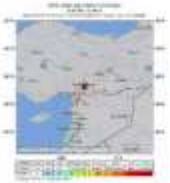
0 0 1 9 1 9

Responses

Contribute to citizen science. Please tell us about your experience

Citizen Scientist Contributions

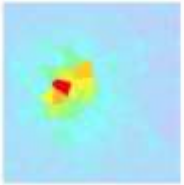
Did You Feel It? IX



Community Internet Intensity Map

Contributed by US [2]

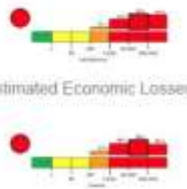
ShakeMap IX



Estimated Intensity Map

Contributed by US [2]

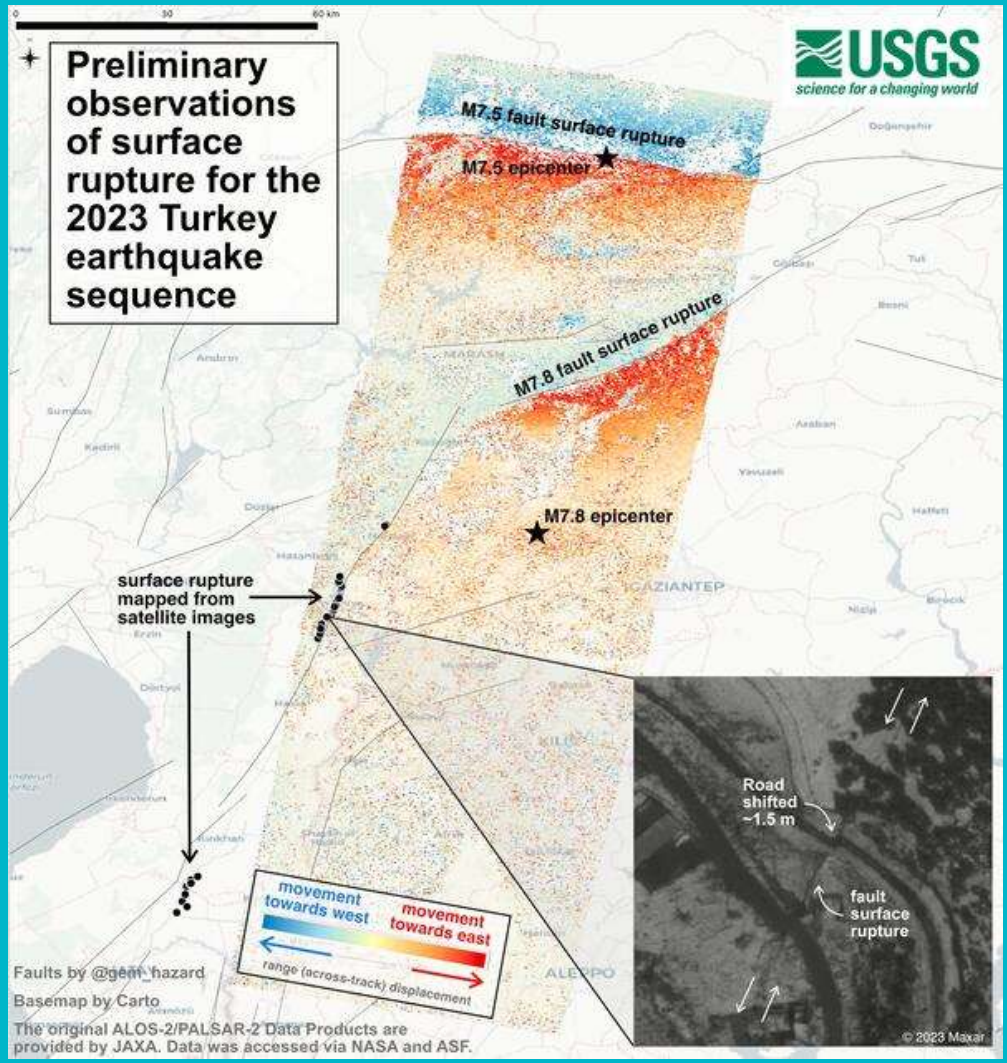
PAGER RED



Estimated Economic Losses

Estimated Fatalities

Contributed by US [2]



DROP where you are onto your hands and knees.

This position protects you from being knocked down and also allows you to stay low and crawl to shelter, if nearby.

COVER your head and neck with one arm and hand.

- If a sturdy table or desk is nearby, crawl underneath it for shelter.
- If no shelter is nearby, crawl next to an interior wall (away from windows).
- Stay on your knees; bend over to protect vital organs.

HOLD ON until shaking stops.

- Under shelter: hold on to your shelter with one hand; be ready to move with it if it shifts.
- No shelter: hold on to your head and neck with both arms and hands.

Source: www.ShakeOut.org

KEEP IN TOUCH

Arkansas Geological Survey

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@ArkansasEE

Complete references are available upon request.

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