

## Topic 5: Earthquakes and Plate Tectonics

<https://geowiki.ucsd.edu/sio15>



**for-credit test #1 on Canvas TODAY!**

optional discussion session (TAs)  
today 4 pm, York 3030

Office hour (Prof. Laske)  
today 5 pm - Zoom

**Homework1 due TOMORROW,**  
submit single pdf on Gradescope,  
assign page # to each problem #

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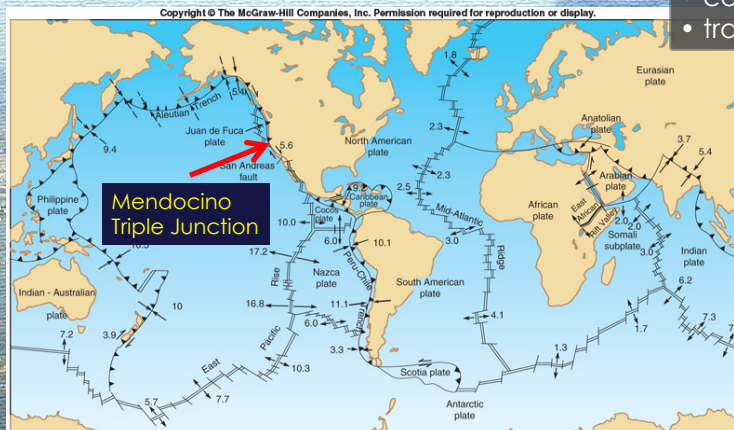
## Lithospheric Plates

Fig 4.19

- lithosphere is broken up into 12 major plates
- move about (a few cm per year)
- driven by mantle convection

### Plate Boundaries

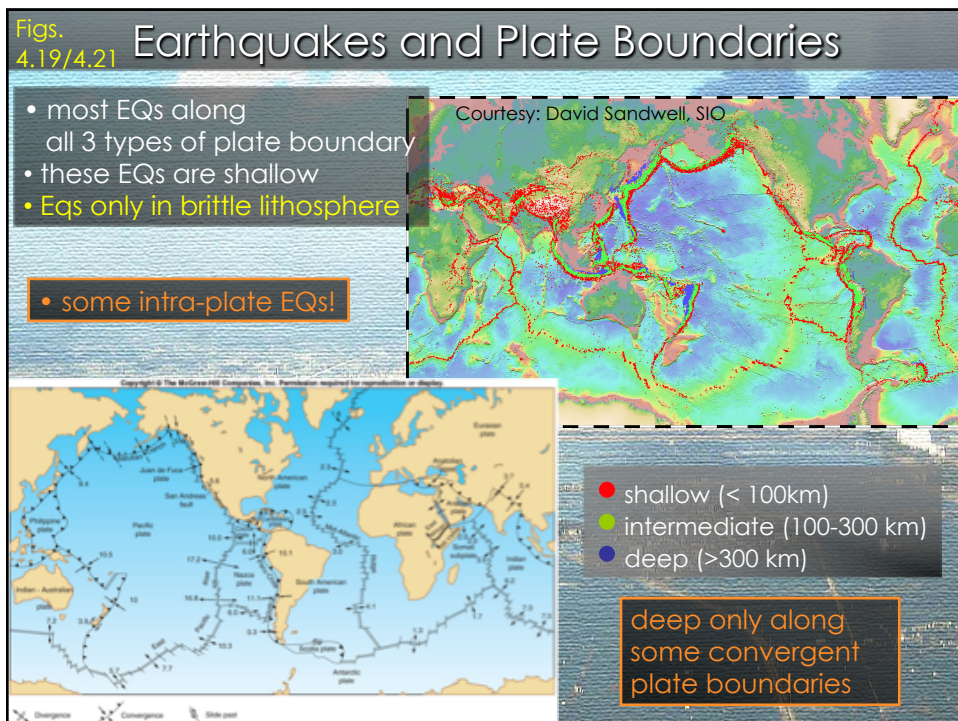
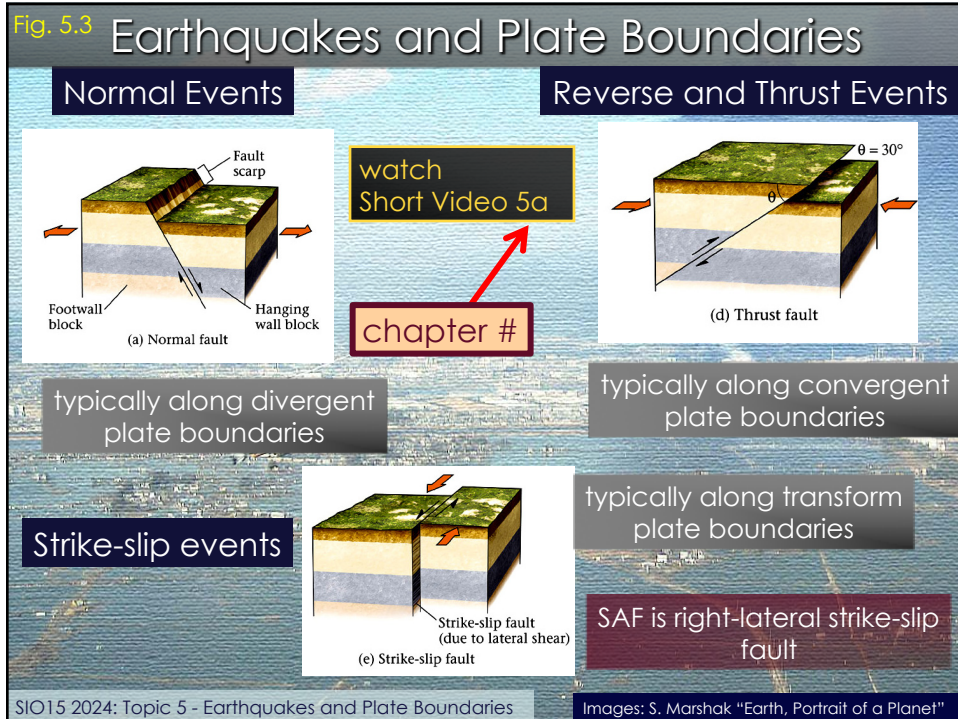
- divergent
- convergent
- transform



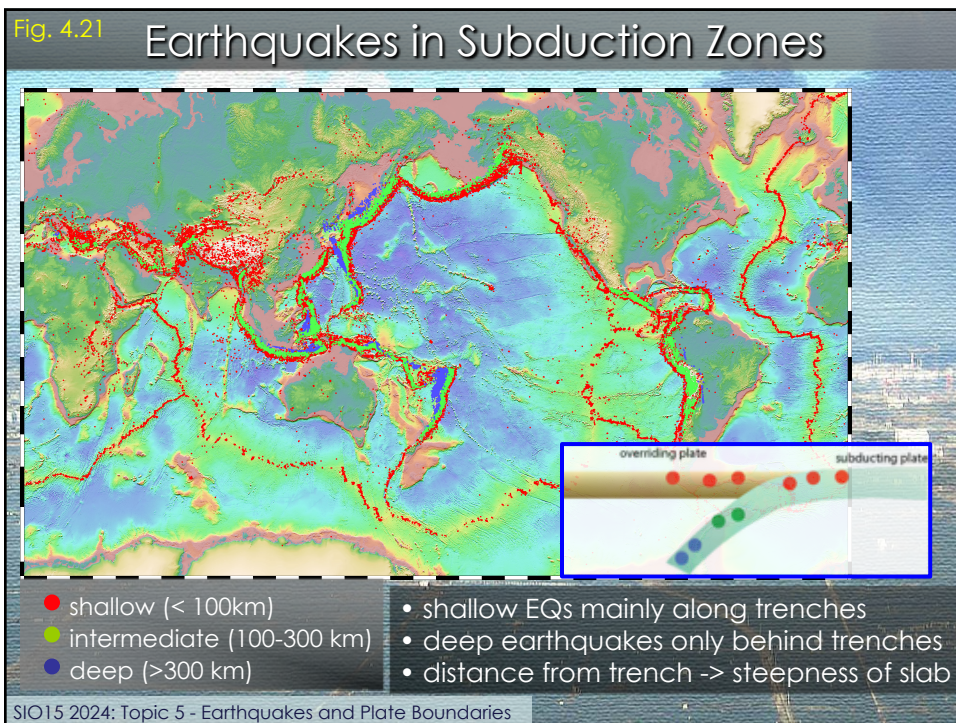
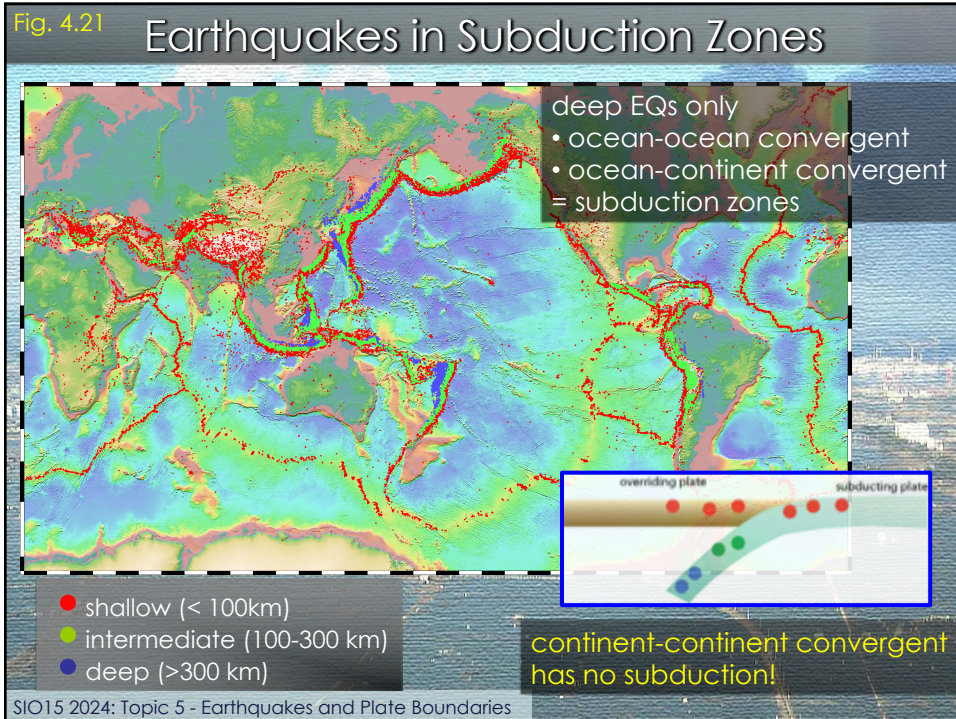
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Divergence Convergence Slide past

Image: P. Abbott "Natural Disasters"









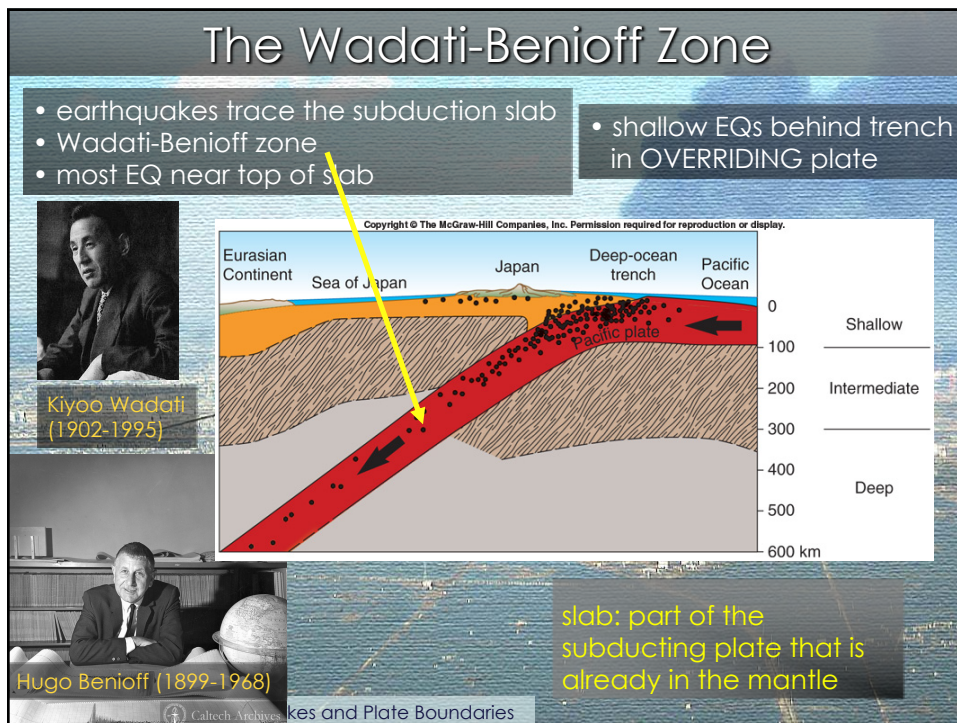
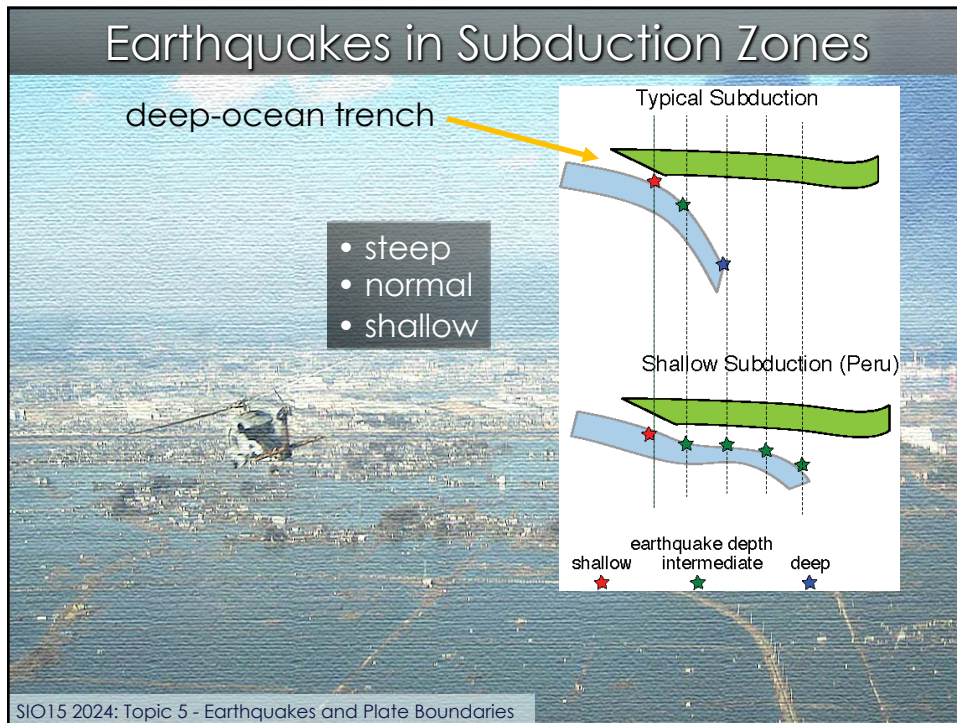
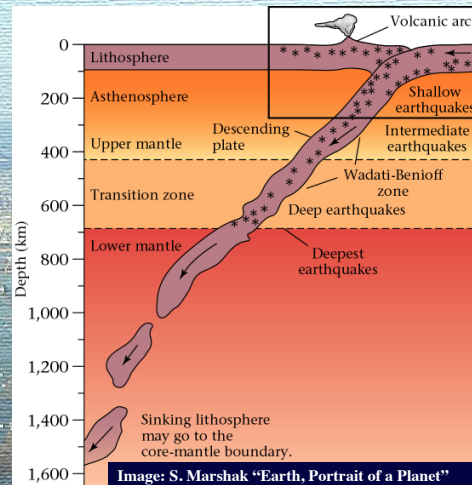




Fig. 4.21

## Earth's Deepest Quakes

- deep earthquakes occur only to 670 km
- below pressure too high for cracks in crust
- deepest EQ due to phase transformations



subducting plate heats up  
→ no longer brittle but ductile

Image: S. Marshak "Earth, Portrait of a Planet"

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## Earth's Largest Quakes

Table 5.1 The 16 Largest Earthquakes in the World since 1900<sup>(9)</sup>

Rank	Location	Date	Magnitude	Plate Boundary
1	Valdivia, Chile	22 May 1960	9.5	Nazca (plate) subduction
2	Prince William Sound, Alaska "Good Friday Earthquake"	28 Mar 1964	9.2	Pacific subduction
3	Sumatra-Andaman, Indonesia	26 Dec 2004	9.1	Indian subduction
4	Tohoku, Japan	11 Mar 2011	9.0	Pacific subduction
5	Kamchatka	04 Nov 1952	9.0	Pacific subduction
6	Maule, Chile	27 Feb 2010	8.8	Nazca subduction
7	Off the Coast of Ecuador	31 Jan 1906	8.8	Nazca subduction
8	Rat Islands, Alaska	04 Feb 1965	8.7	Pacific subduction
9	Northern Sumatra, Indonesia	28 Mar 2005	8.6	Indian subduction
10	Assam, India - Tibet	15 Aug 1950	8.6	India/Asia collision
11	Andreanof Islands, Alaska	09 Mar 1957	8.6	Pacific subduction
12	Southern Sumatra, Indonesia	12 Sep 2007	8.5	Pacific subduction
13	Banda Sea, Indonesia	01 Feb 1938	8.5	Pacific/Indian subduction
14	Kamchatka	03 Feb 1923	8.5	Pacific subduction
15	Chile-Argentina Border	11 Nov 1922	8.5	Nazca subduction
16	Kuril Islands	13 Oct 1963	8.5	Pacific subduction

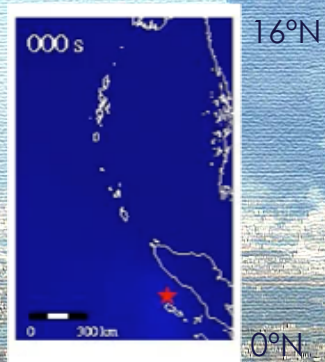
the largest EQs in the last 100 year occurred in subduction zones

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## The Fault Length and the Size of an EQ

rupture propagation  
of 2004 Sumatra-Andaman EQ



- the largest EQs occurred along long faults
- large EQs along short faults are unlikely

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## Poll

Q1 Where in the U.S. do we find the greatest earthquake hazard?

☒ Single Choice ☐ Multiple Choice

California

Alaska

Hawaii

Oklahoma

South Carolina

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## Poll

Q1 Where in the U.S. do we find the greatest earthquake hazard?

no simple answer

☒ Single Choice ☐ Multiple Choice

California	high population density
Alaska	greatest EQs
Hawaii	some Eqs/tsunami risk
Oklahoma	even here
South Carolina	some EQs

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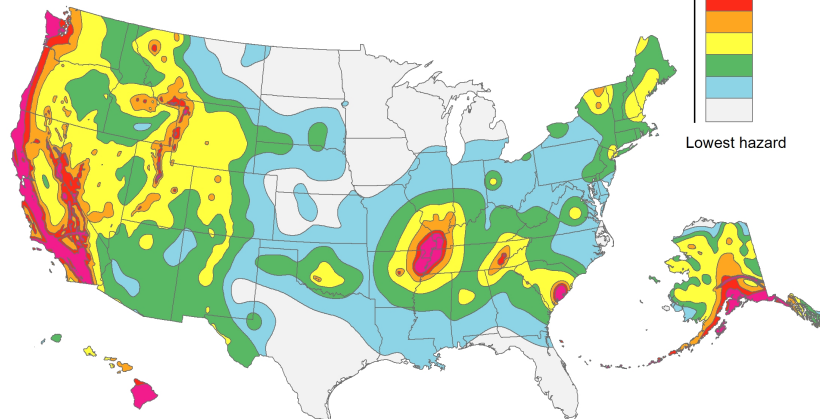
Fig. 6.26  
updated

## Earthquakes in Plate's Interior



PGA 2% in 50 yrs

Highest hazard  
↑  
Lowest hazard



source: USGS

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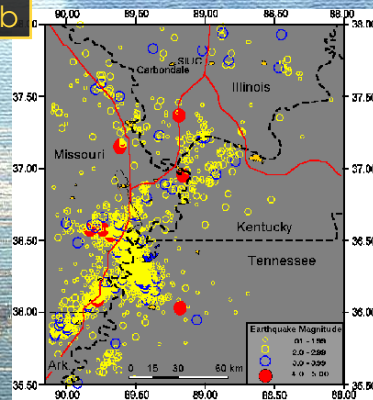
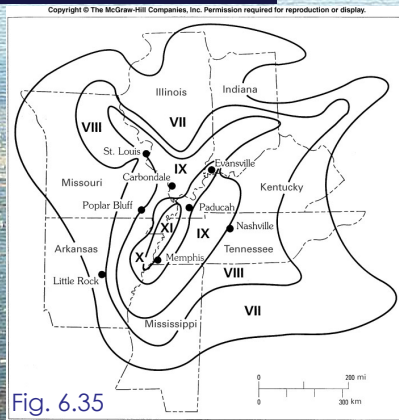
## New Madrid: Earthquakes in Plate's Interior?

Mag 7.9/8.0, 1811/1812;  
Largest U.S. EQ outside of Alaska  
(together with 1857 Fort Tejon, CA)

Earthquakes recorded  
between 1974 and  
1995

### Mercalli Intensity

### Short Video 5b

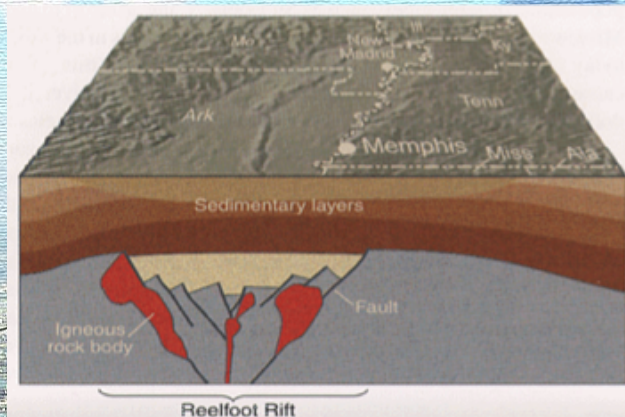


Failed Ancient Rift (~550 my ago)!

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## New Madrid: Earthquakes in Plate's Interior?

Fig. 6.36



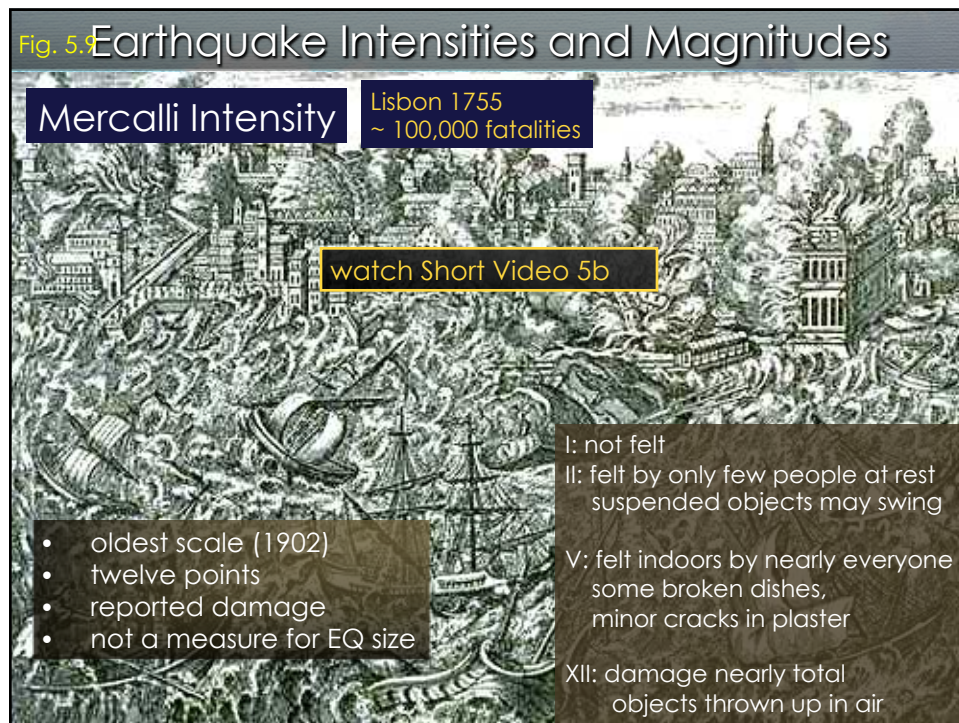
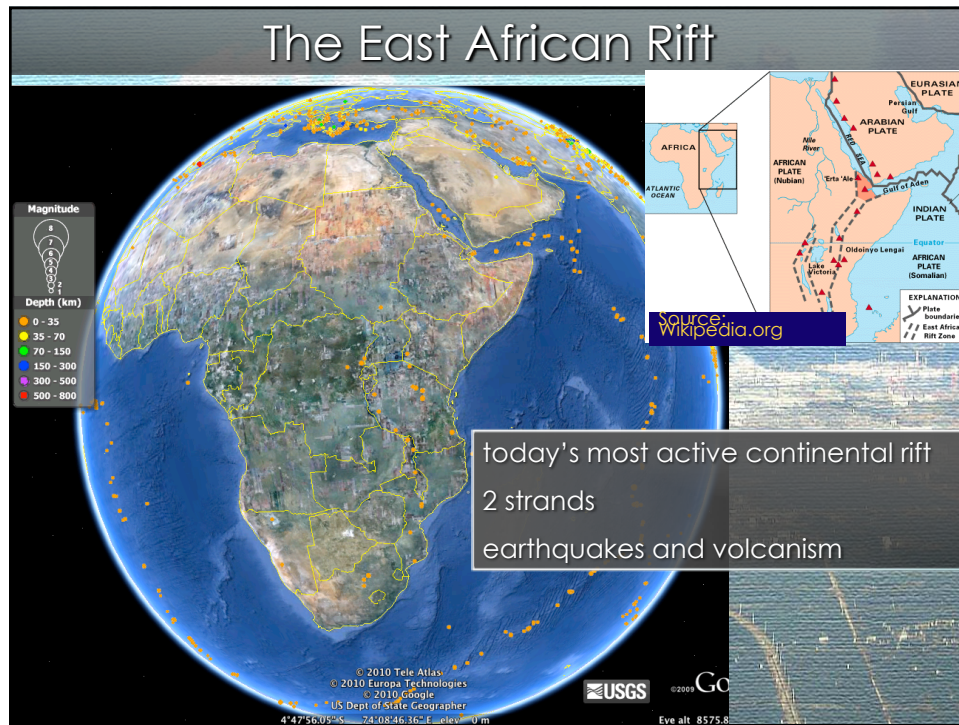
Failed Ancient Rift (~550 my ago)! now buried with sediments

-> faults/weak zone

-> still active today even without active plate boundary

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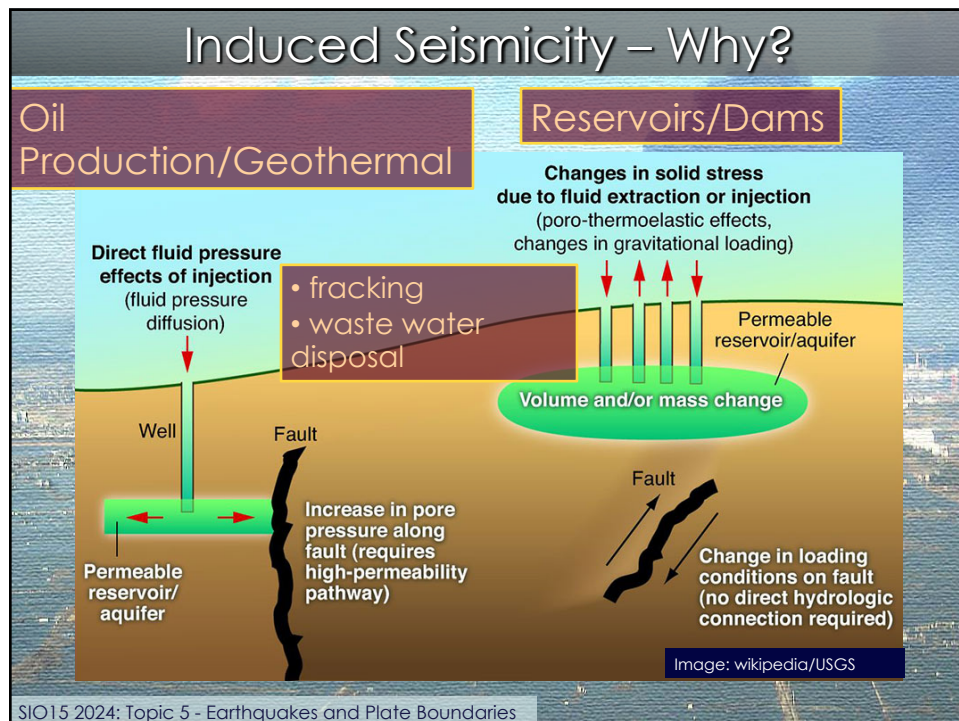
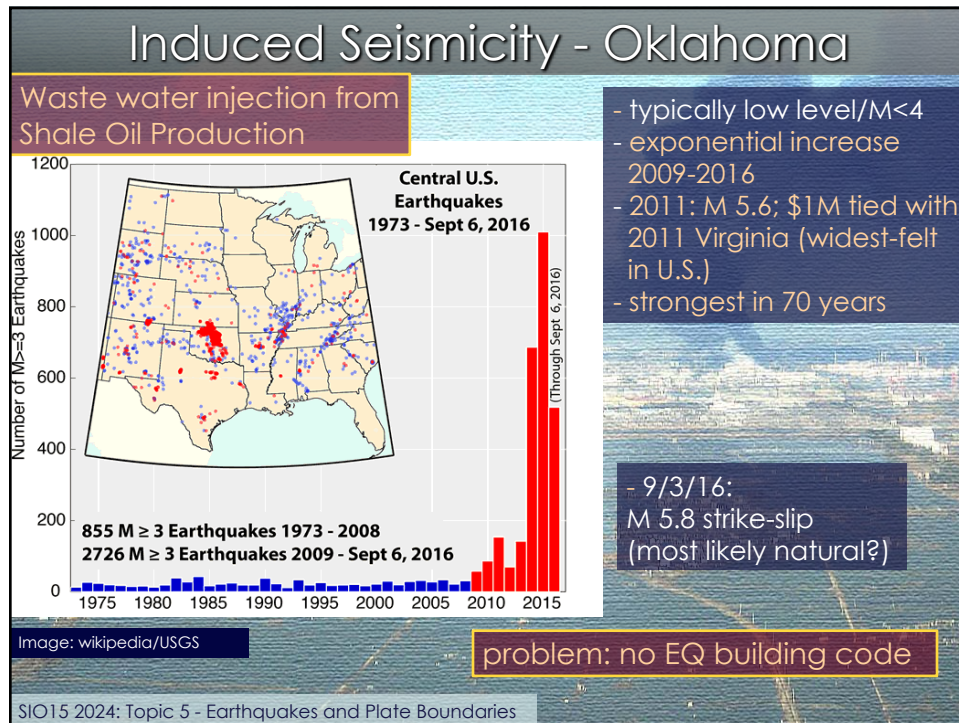




Fig. 5.1 An Earthquake Along a Fault

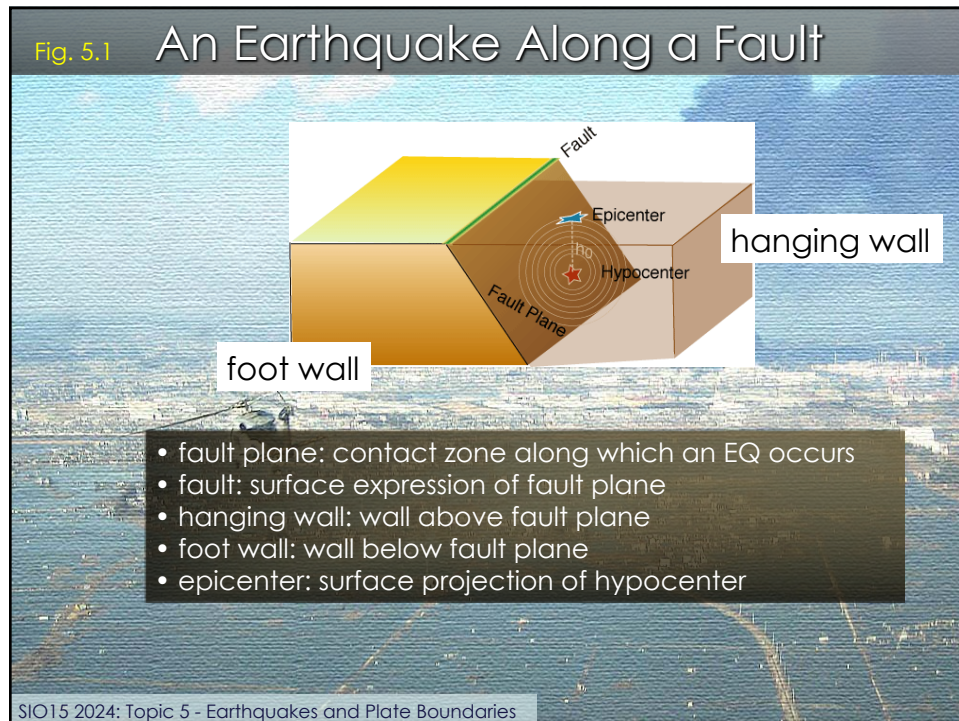
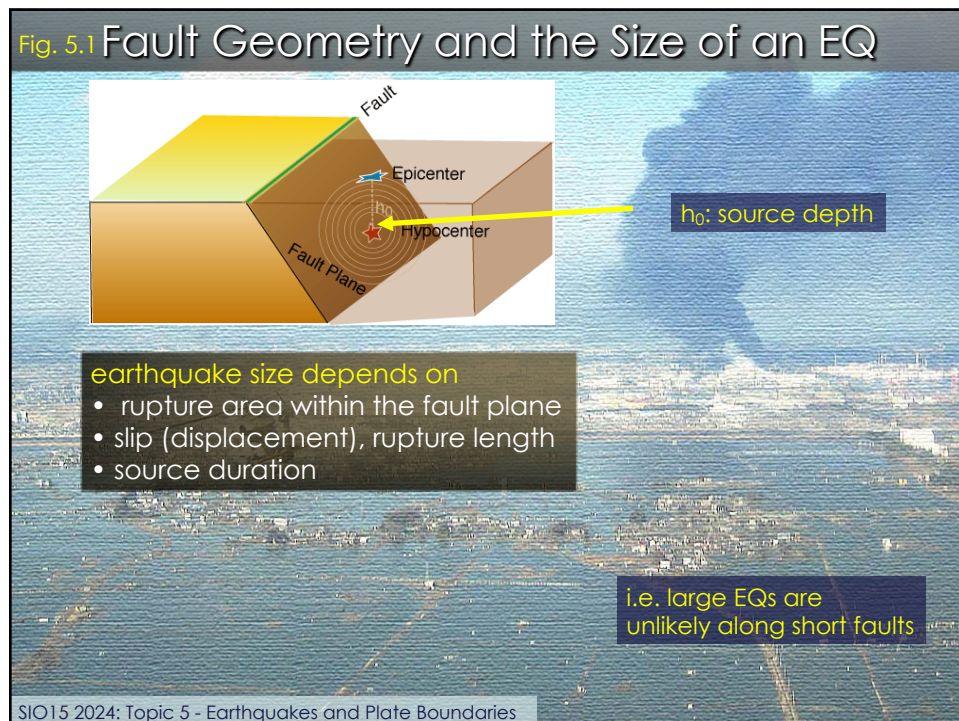


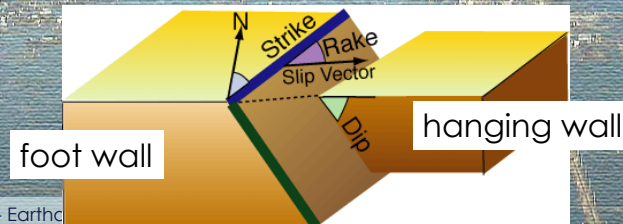
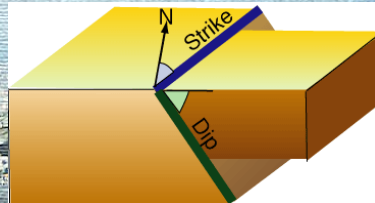
Fig. 5.1 Fault Geometry and the Size of an EQ



## Parameters of an Earthquake Along a Fault

Fig. 5.2

- **strike** (direction of surface trace)
- **dip** (dip of fault plane)
- **rake** (direction of motion of hanging wall)
- **slip vector** (motion of block)



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## How Often Do Earthquakes Occur?

Table 5.5 Annual Worldwide Seismicity by Moment Magnitude (modified from <sup>(3)</sup>)

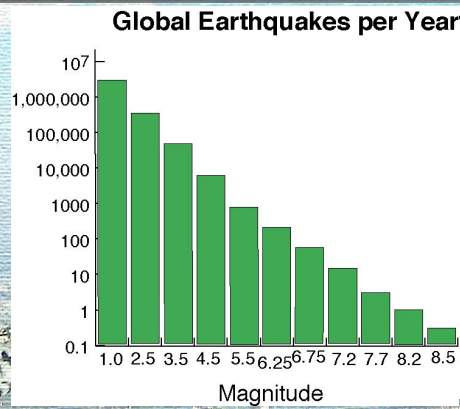
Magnitude	# of EQs/year	Estimated Radiated Seismic Energy ( $\times 10^{17}$ J)
8.5 and up	0.3	11.1
8.0-8.4	1	5.0
7.5-7.9	3	2.7
7.0-7.4	15	2.4
6.6-6.9	56	1.7
6.0-6.5	210	1.4
5.0-5.9	800	0.59
4.0-4.9	6200	0.15
3.0-3.9	49,000	0.04
2.0-2.9	350,000	0.008
0.0-1.9	3,000,000	0.002

- > 3.5 Mio per year
- small events often
- large events rare

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## Earthquake Recurrence Time Fig. 5.13



Get recurrence time from # of EQ per year

E.g. 3 Mio EQ/year  $\rightarrow$  1 EQ every 10.5s  
0.3 EQ/year  $\rightarrow$  1 EQ every 3.3 years

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