## *Earthquakes and Seismic Waves*

Earthquake 2009 November 4

## *Earthquake destruction*

- Intensity of earthquake
- Length of shaking (duration)
- 'Soil' type—the nature of the material upon which the structure rests
- Building design—how well it is designed and built

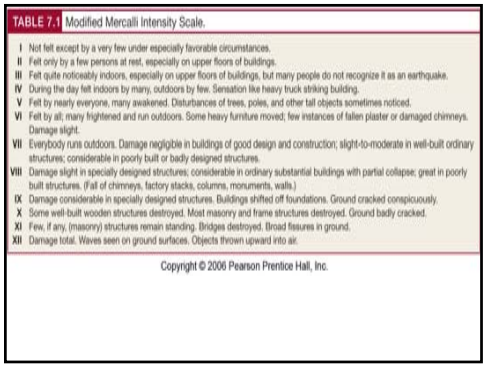


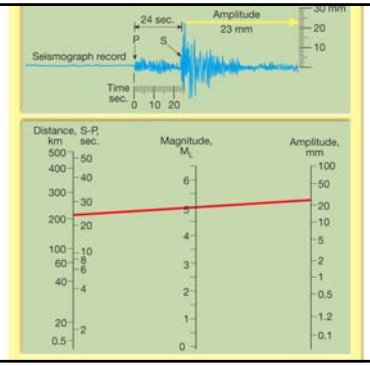
TABLE 7.1 Modified Mercalli Intensity Scale.

I Not felt except by a very few under especially favorable circumstances.
II Felt only by a few persons at rest, especially on upper floors of buildings.
III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake.
IV During the day felt indoors by many, outdoors by few. Sensation like heavy truck striking building.
V Felt by nearly everyone, many awakened. Disturbances of trees, poles, and other tall objects sometimes noticed.
VI Felt by all; many frightened and run outdoors. Some heavy furniture moved; few instances of fallen plaster or damaged chimneys. Damage slight.
VII 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.
VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. (Fall of chimneys, factory stacks, columns, monuments, walls.)
IX Damage considerable in specially designed structures. Buildings shifted off foundations. Ground cracked conspicuously.
X Some well-built wooden structures destroyed. Most masonry and frame structures destroyed. Ground badly cracked.
XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground.
XII Damage total. Waves seen on ground surfaces. Objects thrown upward into air.



## *Magnitude*

- Richter Magnitude
  - Size of waves recorded on the seismograph
  - Corrected for distance from quake
- Moment Magnitude
  also includes:
  - Size of surface rupture
  - Nature of material transmitting the seismic waves
- Both in contrast to number on Mercalli intensity scale, that refers to what are the effects in a location



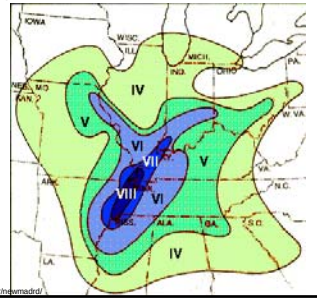

## *Destruction from*

- Ground shaking
- Landslides and subsidence
- Liquefaction
- Tsunami
- Fire

## *Charleston, SC*

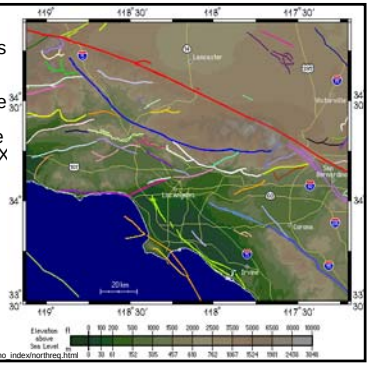
## *Intensity of New Madrid, MO*

- 1811-1812
- $M_L$ to 7.8
- Altered course of Mississippi River
- Toppled chimneys in Cincinnati and Richmond




- http://hsv.com/genlintr/newmadrid/

- Northridge Hills Fault is the pale purple crossing the pink y-shaped one making an X shape just north of US 101



http://www.data.scec.org/chrono_index/northreq.html

## *Northridge 1994 January 17*

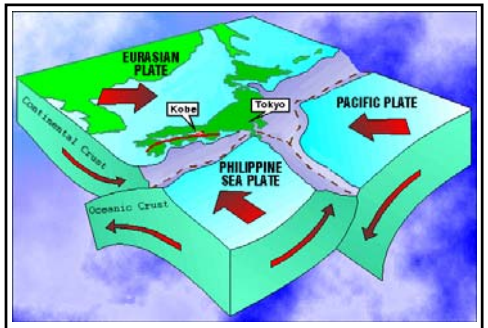
Figure 6.21
Damage to Interstate 5 during the January 17, 1994 Northridge earthquake. (Photo by John Barr/Gamma Liaison)

- http://www.geo.lsa.umich.edu/~crlb/COURSES/107/Lec7/lec7.html

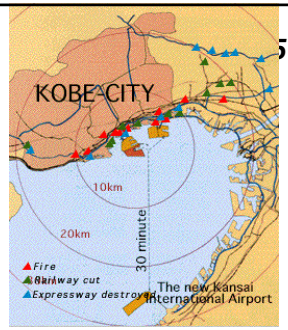
- http://www.data.scec.org/chrono_index/northreq.html

- http://www.data.scec.org/chrono_index/northreq.html

- http://www.vibrationdata.com/earthquakes/northridge.htm



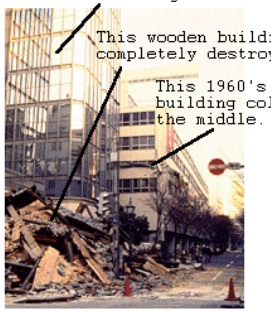

- http://www.georesources.co.uk/kobehigh.htm



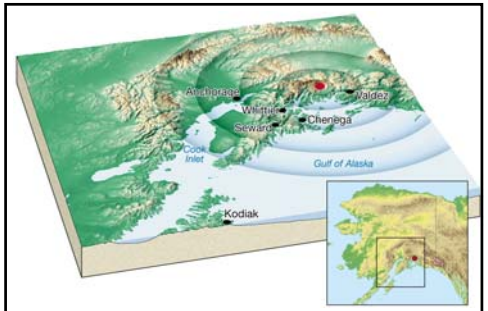

- http://vathena.arc.nasa.gov/curric/land/kobe.html

- http://www.dis-inc.com/kobe.htm

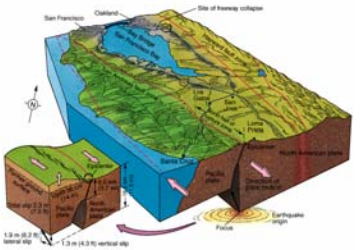
This new building survived intact.




- http://www.georesources.co.uk/kobehigh.htm




## *Loma Prieta 1989*



- http://jamaica.u.arizona.edu/ic/nats101/lectures/ch09/FIG09_019A.JPG

- http://www.dola.state.co.us/oem/PublicInformation/EARTHQUAKE.HTM

- http://pubs.usgs.gov/dds/dds-29/

## *Sumatra, September 2009*

- http://www.time.com/time/world/article/0,8599,1927623,00.html

•http://www.monstersandcritics.com/news/asiapacific/features/article_1505000.php/In-Pictures-Indonesia-Earthquake-October-4th?page=9

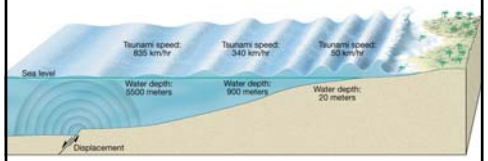
•http://www.life.com/image/90350637

## *Loma Prieta mud volcanoes*

- Liquefaction

- http://www.uwsp.edu/geo/faculty/ozsvath/images/liquefaction_photo.htm

## *Tsunami formation*




## *Samoa, 2009*

- http://www.time.com/time/photogallery/0,29307,1926846,00.html

- http://www.time.com/time/photogallery/0,29307,1926846,00.html

## *Tsunami Indonesia 2004*



## *Tsunami Indonesia 2004*

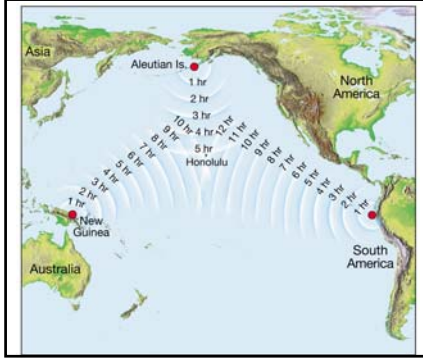


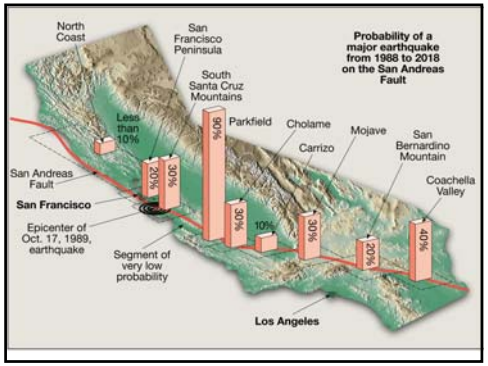

**TABLE 7.2** Earthquake Magnitudes and Expected World Incidence.

| Richter Magnitudes | Effects Near Epicenter | Estimated Number |
|---|---|---|
| <2.0 | Generally not felt, but recorded. | 600,000 |
| 2.0-2.9 | Potentially perceptible. | 300,000 |
| 3.0-3.9 | Felt by some. | 49,000 |
| 4.0-4.9 | Felt by most. | 6200 |
| 5.0-5.9 | Damaging shocks. | 800 |
| 6.0-6.9 | Destructive in populous regions. | 266 |
| 7.0-7.9 | Major earthquakes. Inflict serious damage. | 18 |
| 8.0 and above | Great earthquakes. Destroy communities near epicenter. | 1.4 |

Source: *Earthquake Information Bulletin* and others.

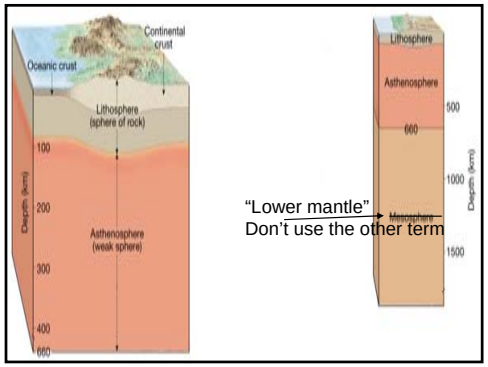


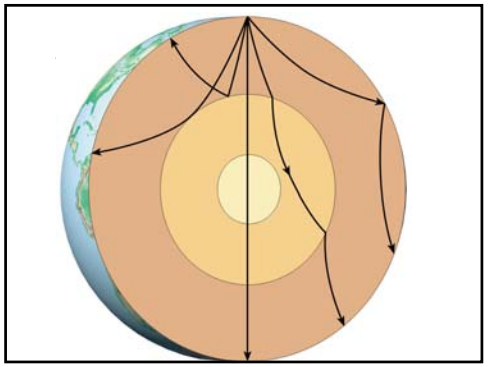
- 2009 so far (Nov 3, 2009)
- 33 @ 6.0 to 6.9
- 14 @ 7.0-7.9 (many in Indonesia, South Pacific)
- 1 @ 8.1 Samoa: September 29

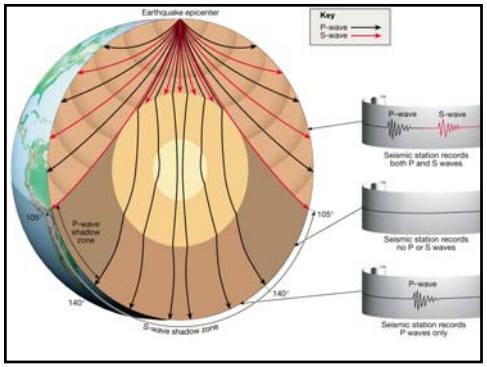


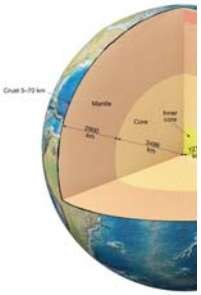

## *Seismic waves tell us about Earth's interior*

- Speed changes with composition, properties, pressure
- Refract at boundaries within Earth
- Some penetrate all types of material, some only penetrate solids
- Our "MRI" of Earth





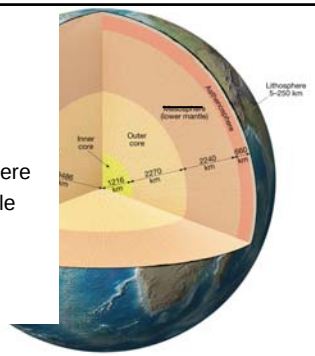



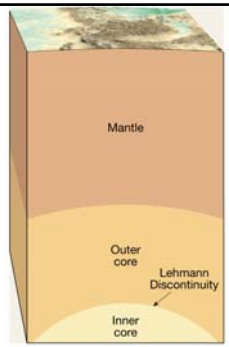
Defined by chemical composition

Crust
Mantle
Core

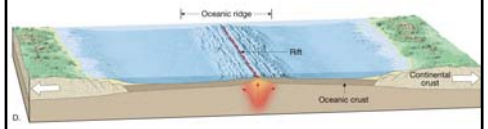
Defined by Physical Properties

Lithosphere
Asthenosphere
Lower mantle
Outer core
Inner core

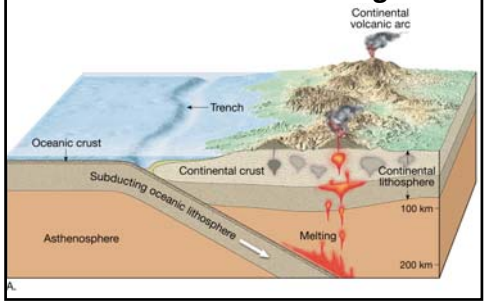


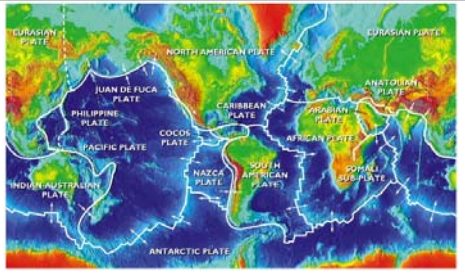




## *Ocean with central ridge*




## *Ocean-Continent Convergence*




- http://earth.geol.ksu.edu/sgao/g100/plots/0829_08_plates.jpg