Natural Hazards and Disaster

Natural Hazards and Disaster

Lab in Class 7: Disaster Risk Management

- Disaster Risk Governance Cycle
- Supporting Observations
- Assessing Threat Relevance

Lab: Disaster Risk Management

1. Discuss the different phases of the Disaster Risk Governance cycle and relate these to hazards, disasters, and the processes that link hazards and disasters

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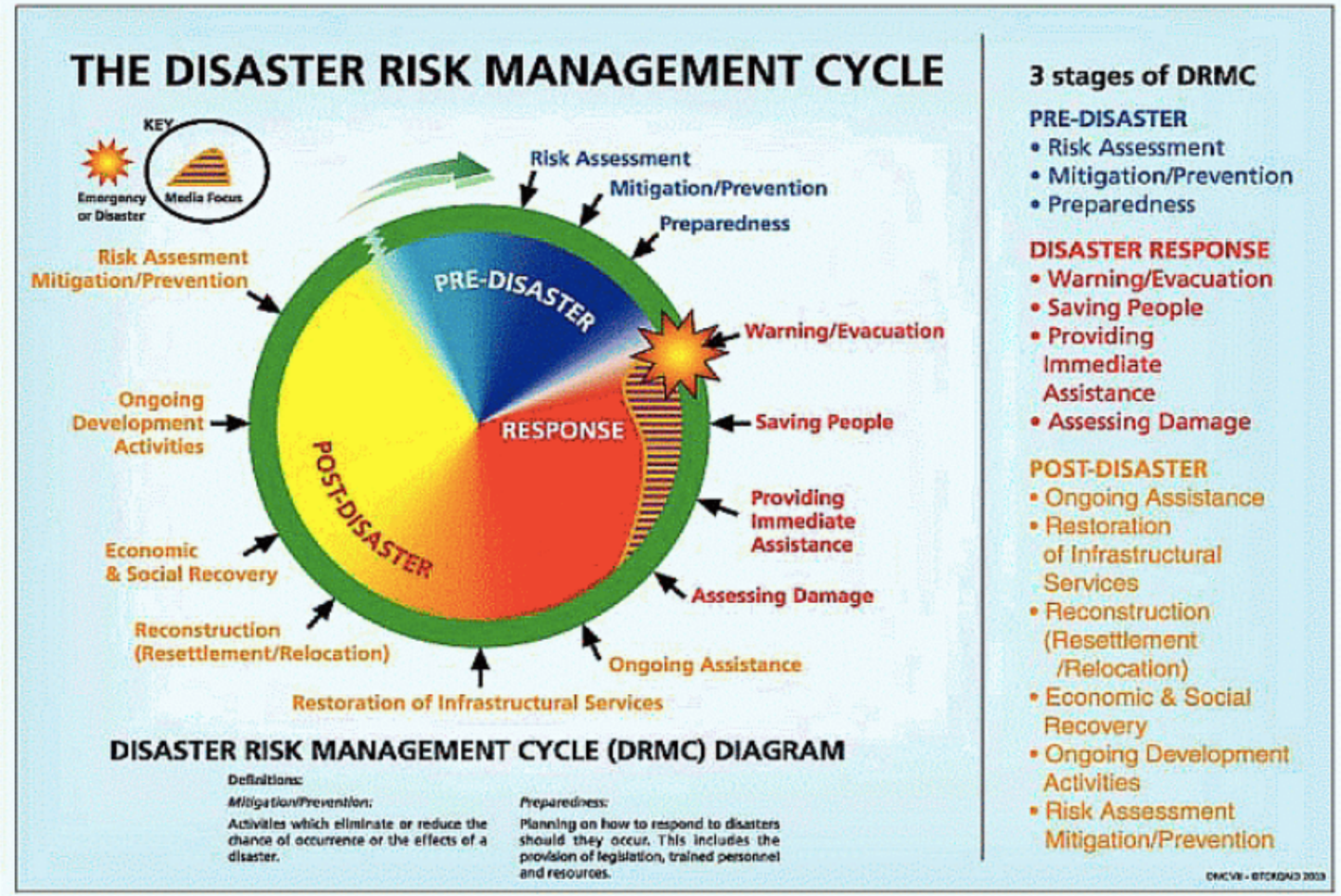

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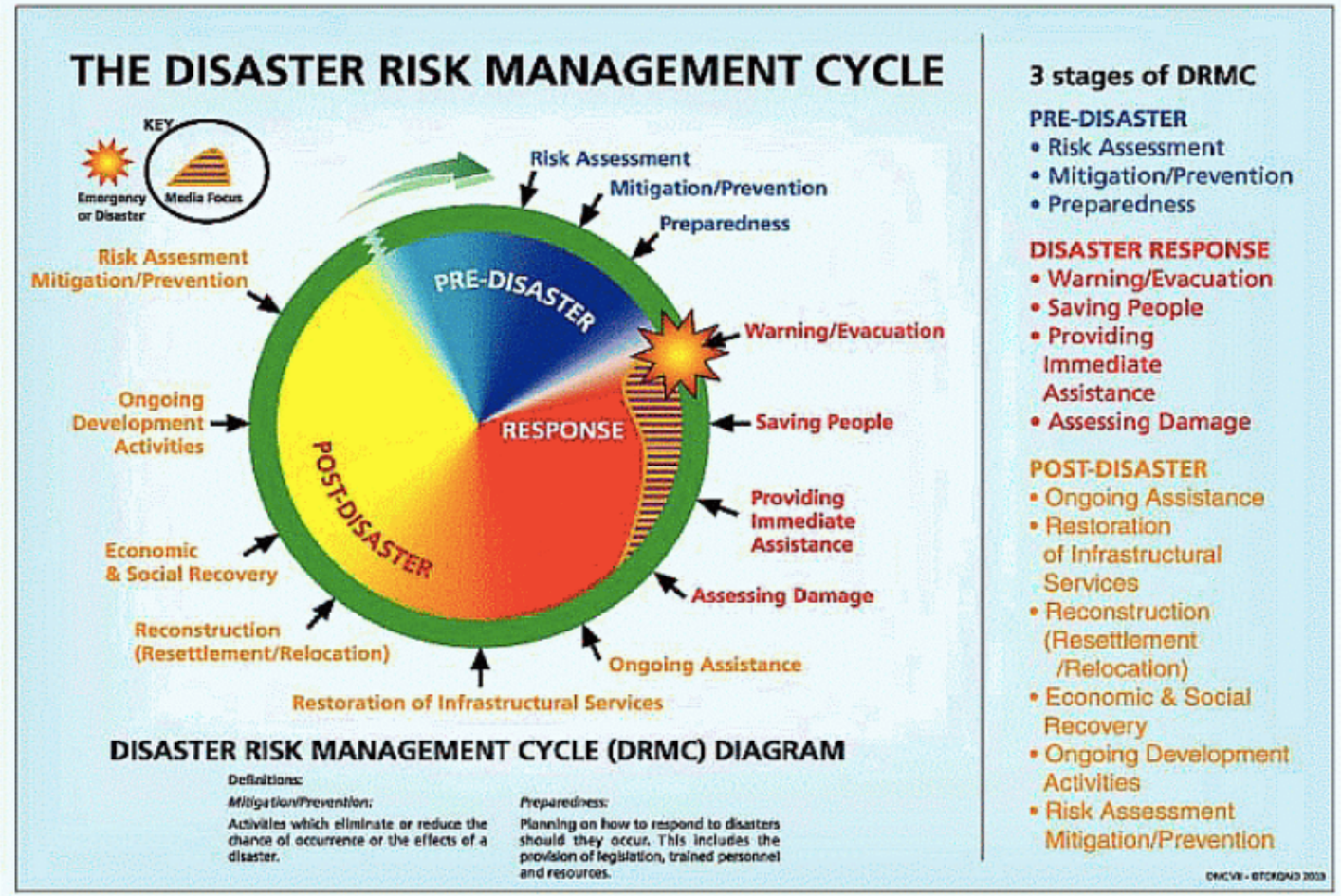

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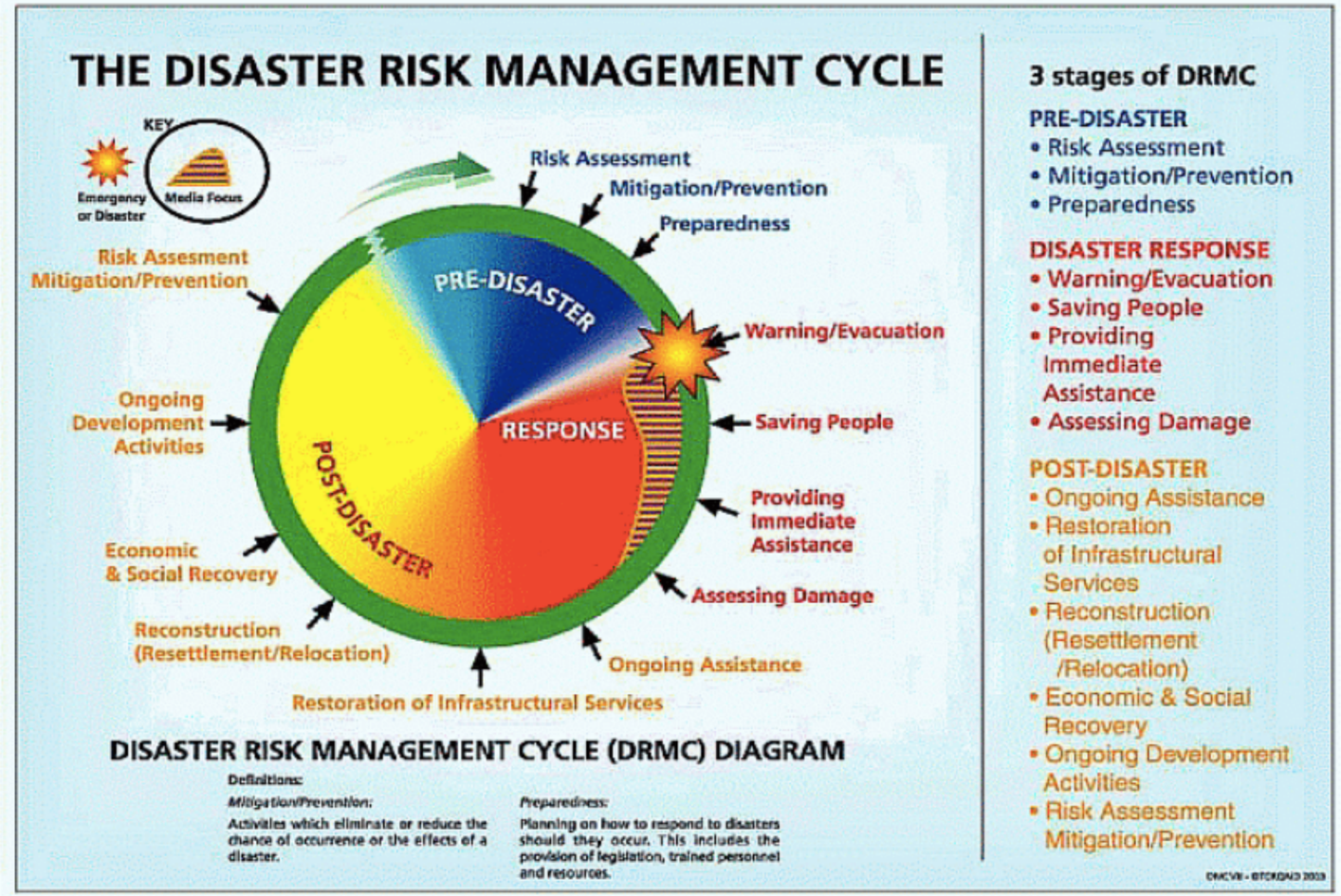
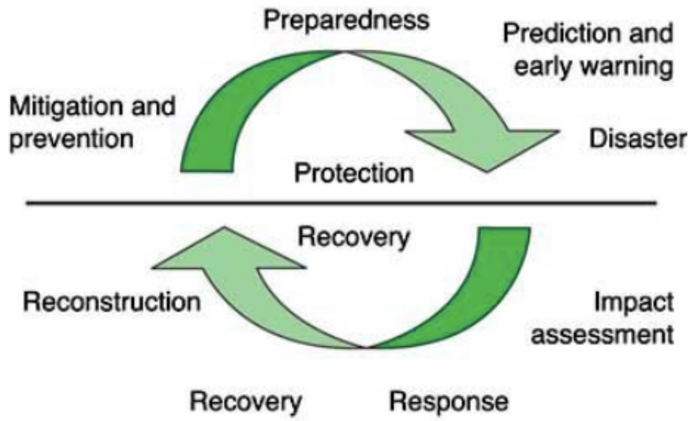


RISK MANAGEMENT



CRISIS MANAGEMENT

2. Describe the main components of the observing system that provides data to inform risk management.

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Observation types:

Sensor-based:

- In situ: observations of ambient conditions (e.g., thermometer)
- Remote sensing: Using a signal to sense something in the distance (e.g., radar)

Sample-based:

- in situ
- in laboratory
- counting, assessing

Mode:

- on the Earth surface (fixed and moving);
- satellite-borne
- dedicated air-borne, ship-borne
- opportunity (ships, airplanes, …)
- balloons, robots, drones (within atmosphere, ocean, …)
- citizen scientists
- Big Data

3. Comment on the relative importance of hazards that originate in space outside the Earth.

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- Near-Earth Objects: Meteoroids, asteroids and comets with orbits that intersect Earth's orbit.
- Meteoroids and asteroids: Fragments of rock and/or metal in space. The smaller fragments generate light as meteors as they pass through Earth's atmosphere. Larger fragments land as meteorites.
- Comets: Balls of ice, dust, and rock that normally reside beyond the orbit of Neptune.
- Bollides: Meteoroids and cometary fragments that explode on entering Earth's atmosphere.
- Solar storms and space weather: Solar flares and coronal mass ejections occur frequently and can disrupt telecommunications or have more severe consequences for electrical and electronically infrastructure.
- Gamma Ray bursts: Extremely energetic explosions that have been observed in distant galaxies
- Extraterrestrial intelligence:
- Human space debris: debris of satellites and rockets

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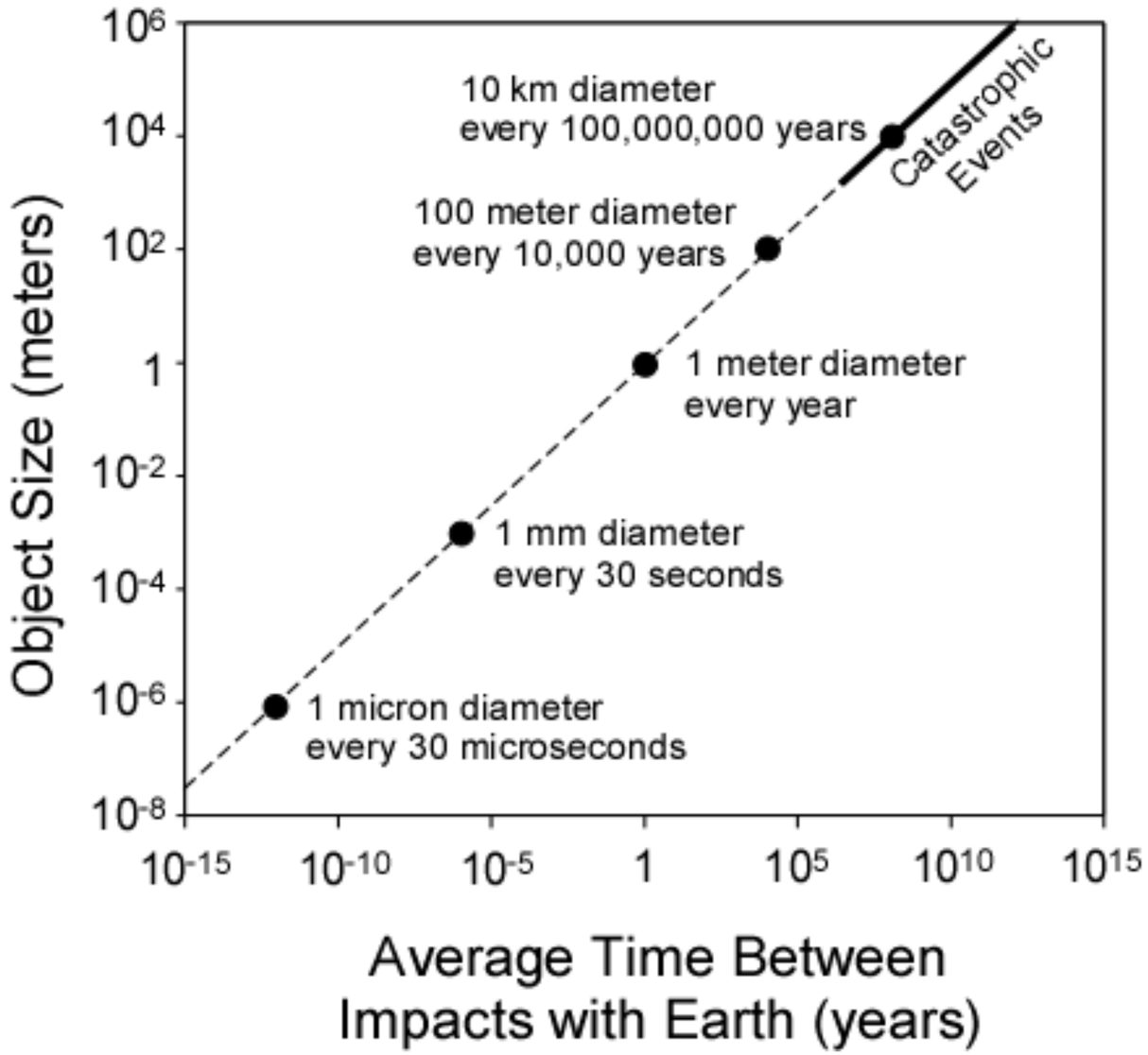

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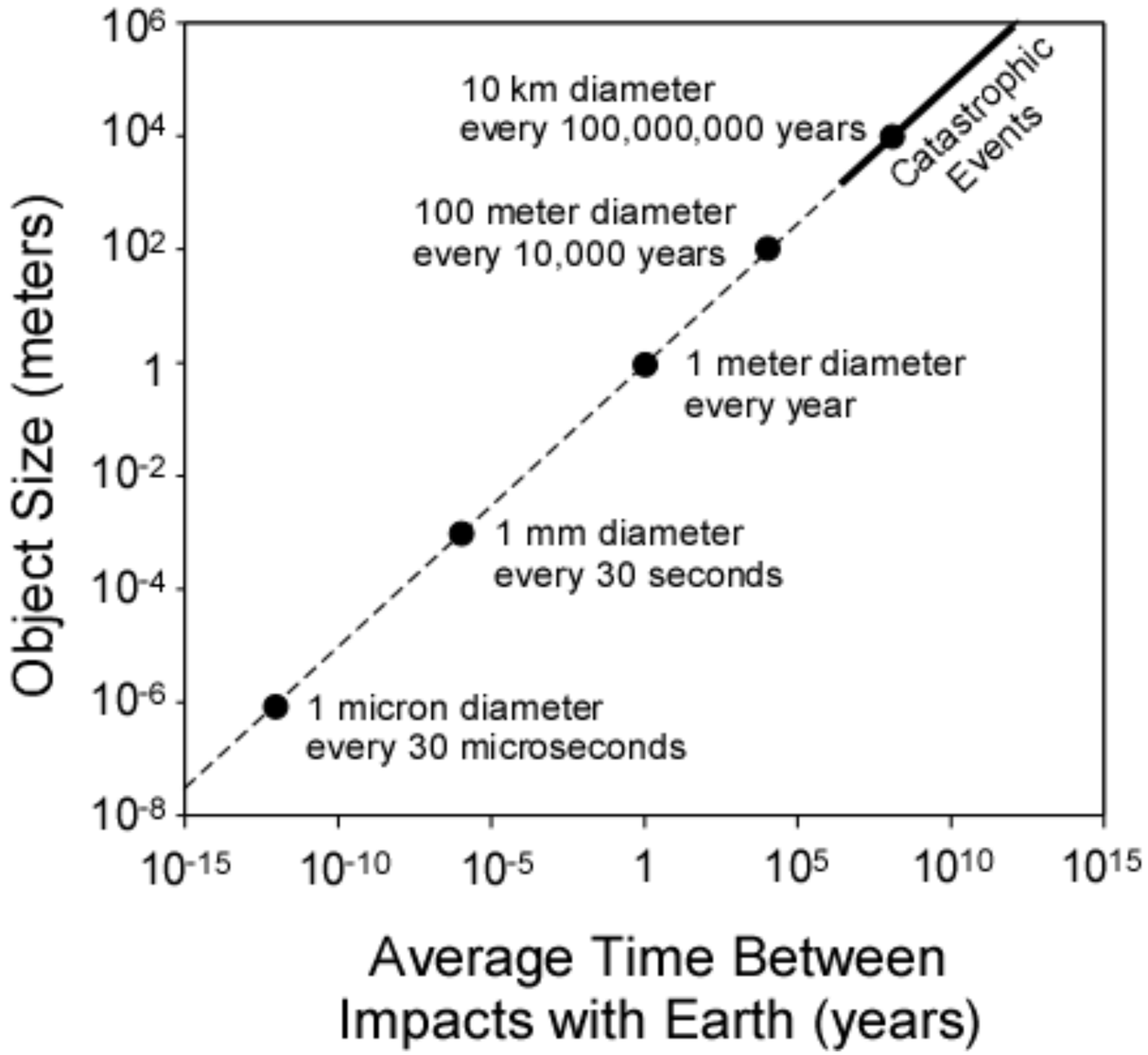
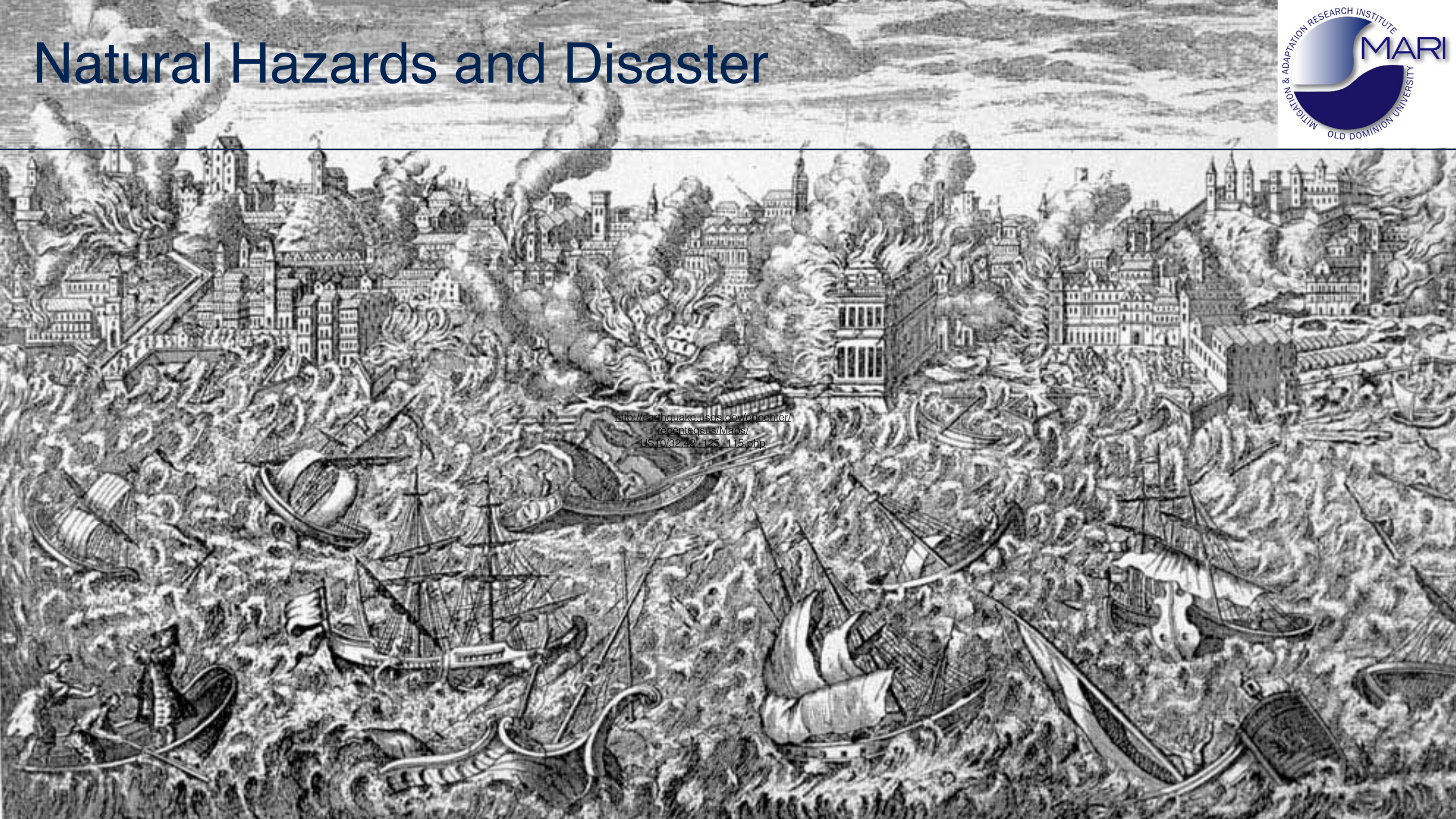


Solar storms?

Natural Hazards and Disaster



http://earthquake.usgs.gov/epcenter/recenteqsus/Maps/US/10/32.42-125.-115.php

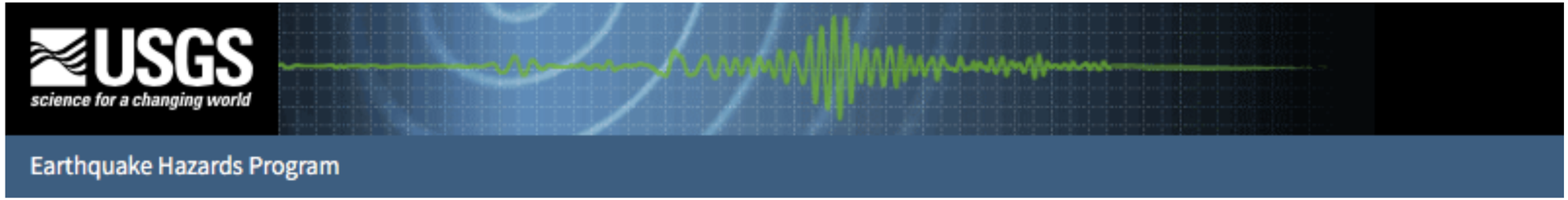
Natural Hazards and Disaster

Class 7: Earthquakes

- Location
- Causes
- Magnitude
- Ground shaking
- Recurrence intervals
- Hazard maps

http://earthquake.usgs.gov/eqcenter/recenteqsus/Maps/US10/32.42-125.-115.php

Earthquakes

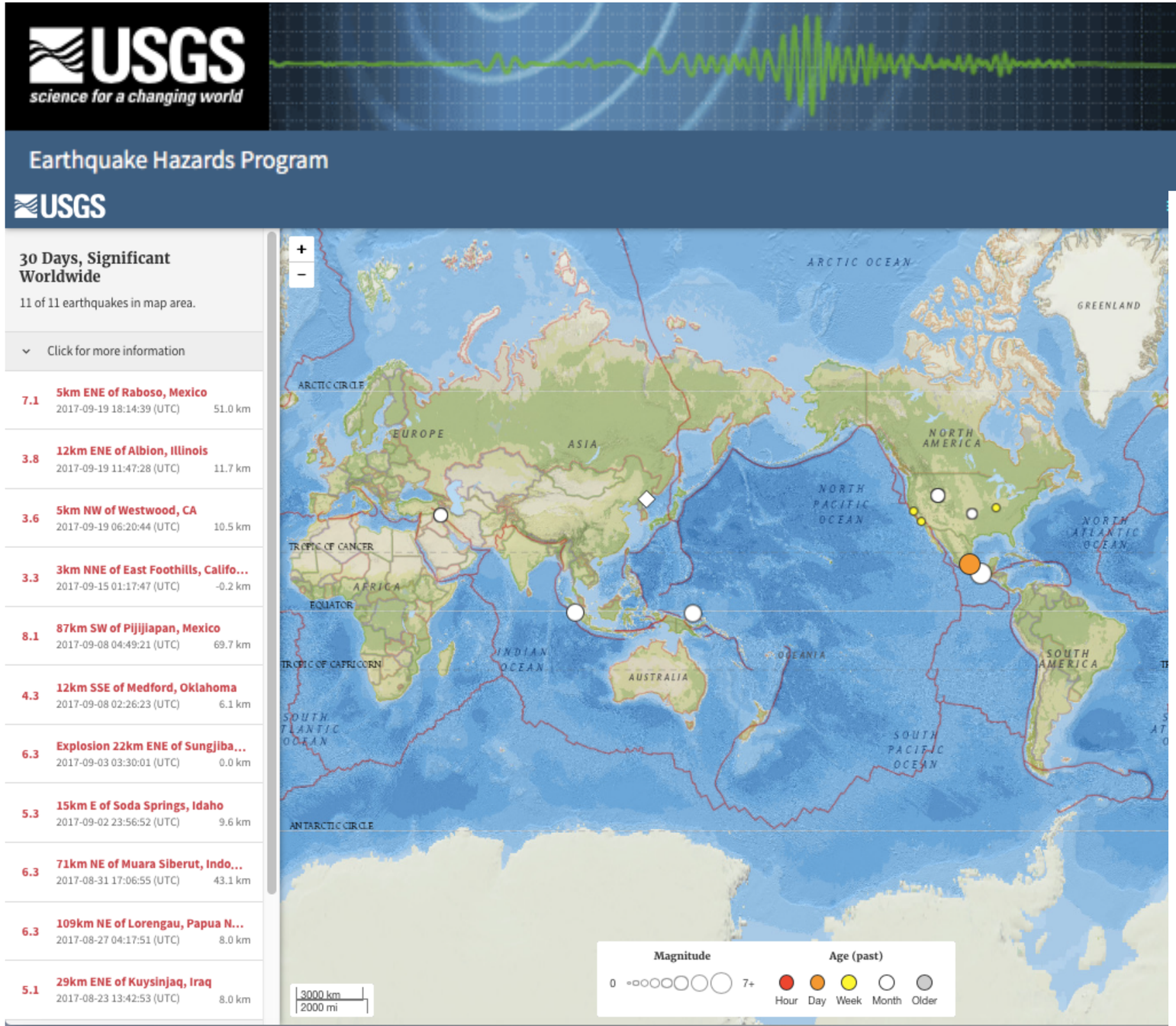


http://earthquake.usgs.gov

Last month

24 hours

Earthquakes



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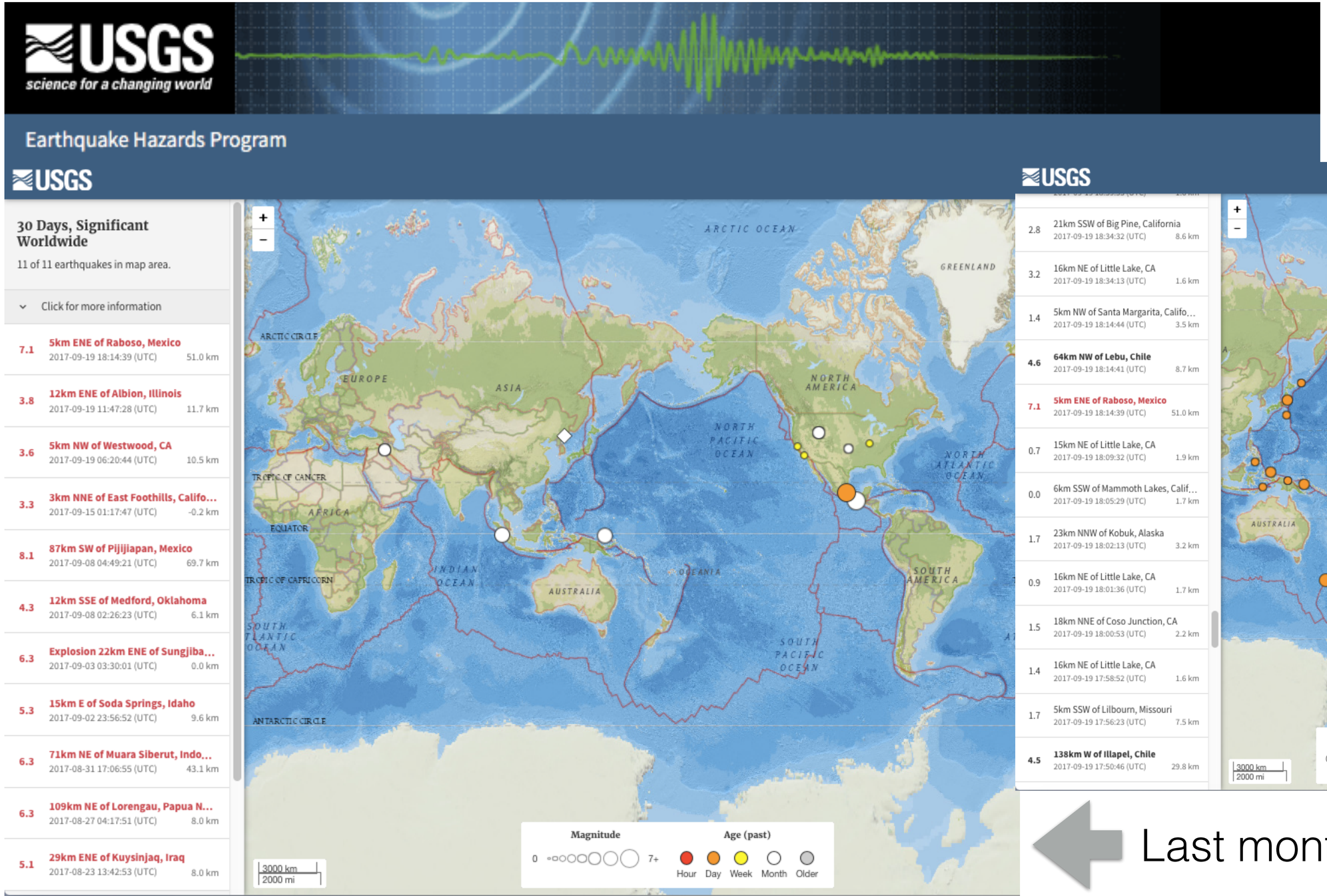

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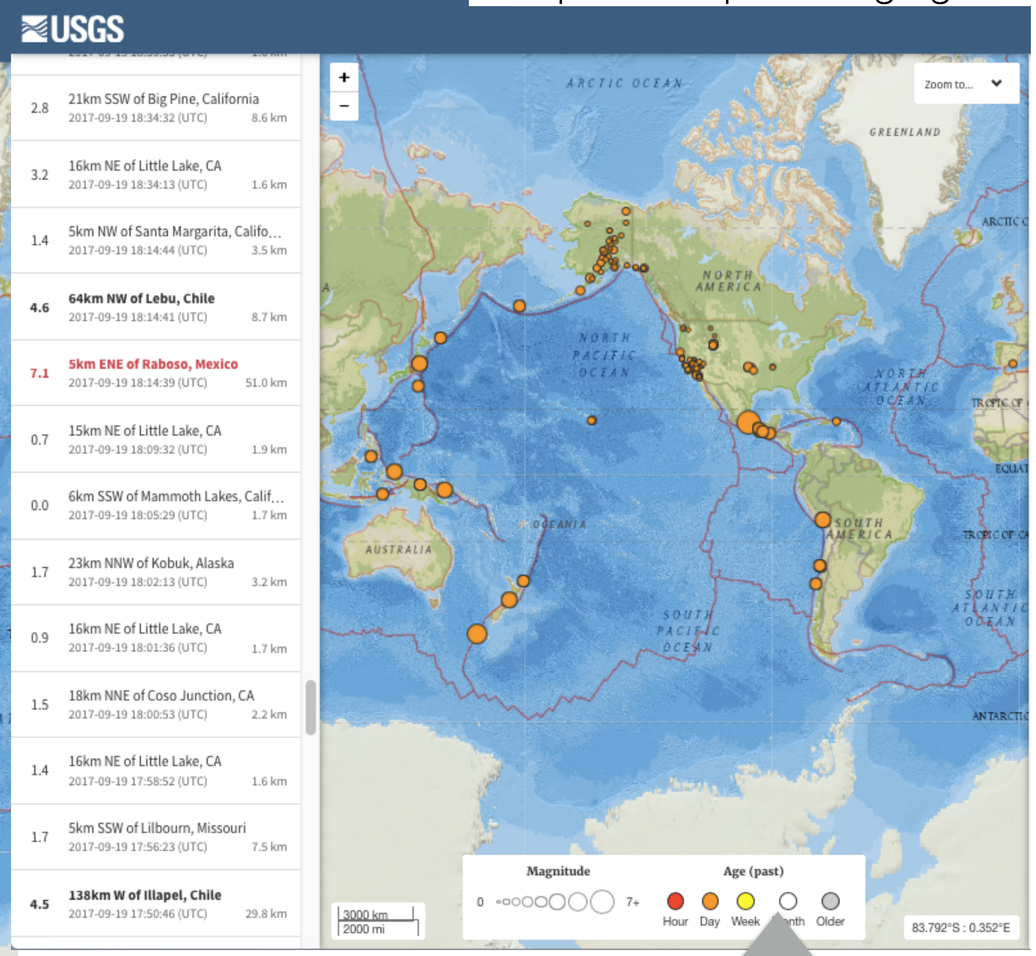

Last month

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Specifying the location of the earthquake

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Epicenter: Latitude, longitude; position on the ground directly above the earthquake

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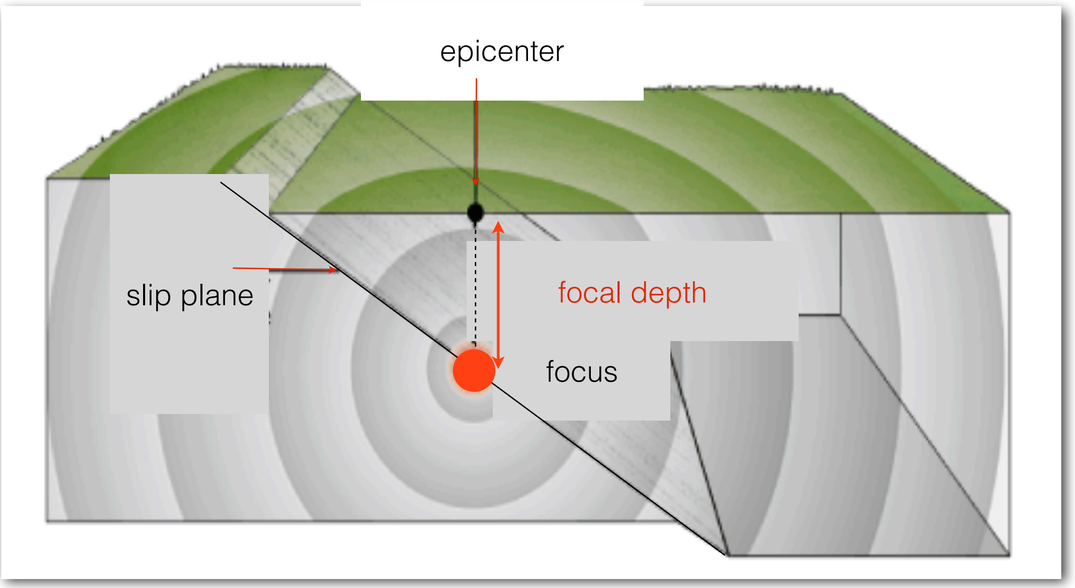
Focal Depth: depth below ground surface where earthquake rupture occurs

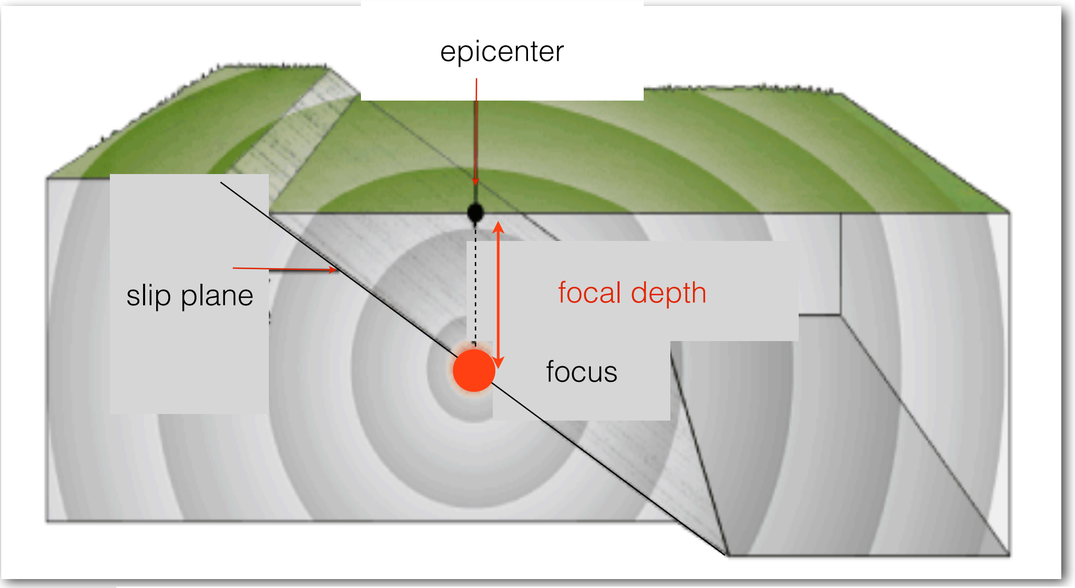


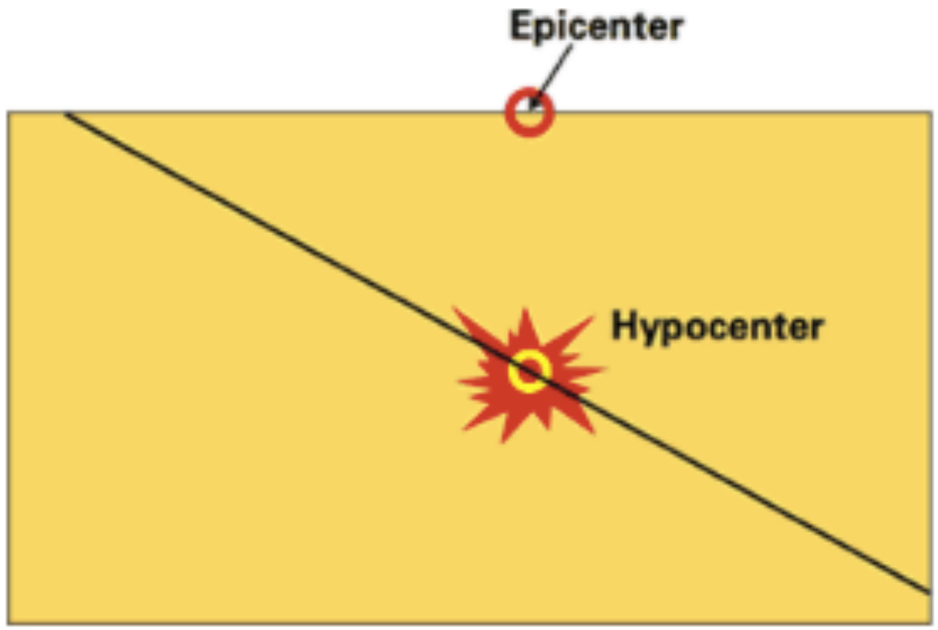
Specifying the location of the earthquake

Epicenter: Latitude, longitude; position on the ground directly above the earthquake

Focal Depth: depth below ground surface where earthquake rupture occurs

Hypocenter (focus): Actual location in the Earth's crust where the earthquake occurs (needs lat, long, and depth)





Earthquake Location

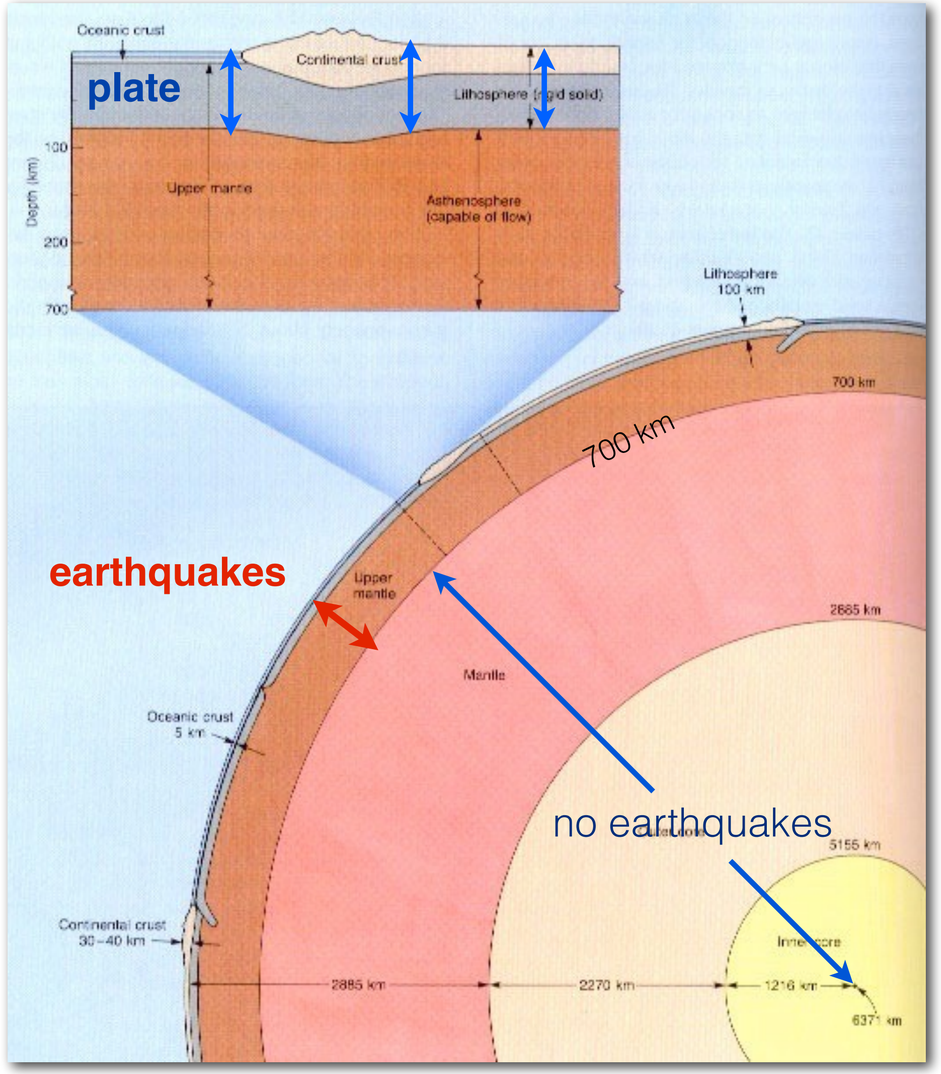
Tectonic Plates are cool, thin and ‘rigid,’ relative to the hot, ductile mantle beneath

plate = crust + lithosphere

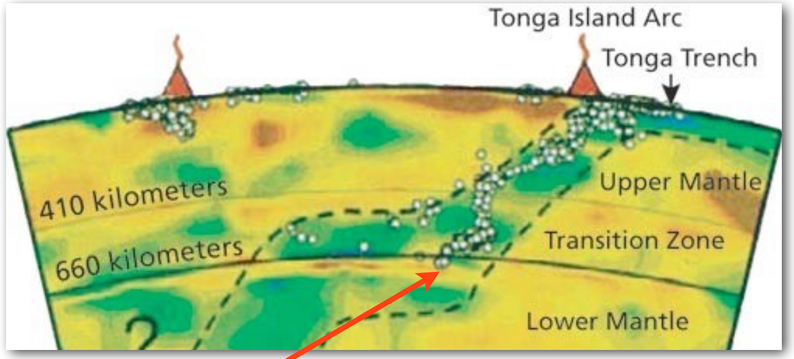
Shallow earthquakes: <70 km

Intermediate: >70 to 300 km

Deep: >300 km



http://www.angelfire.com/wv/permianpark/images/fullearth.jpg



http://www.whoi.edu/cms/images/lstokey/2005/1/v42n2-detrick2en_5301.jpg

Deepest known are at ca. 700 km

Earthquake Location

Tectonic Plates are cool, thin and 'rigid,' relative to the hot, ductile mantle beneath

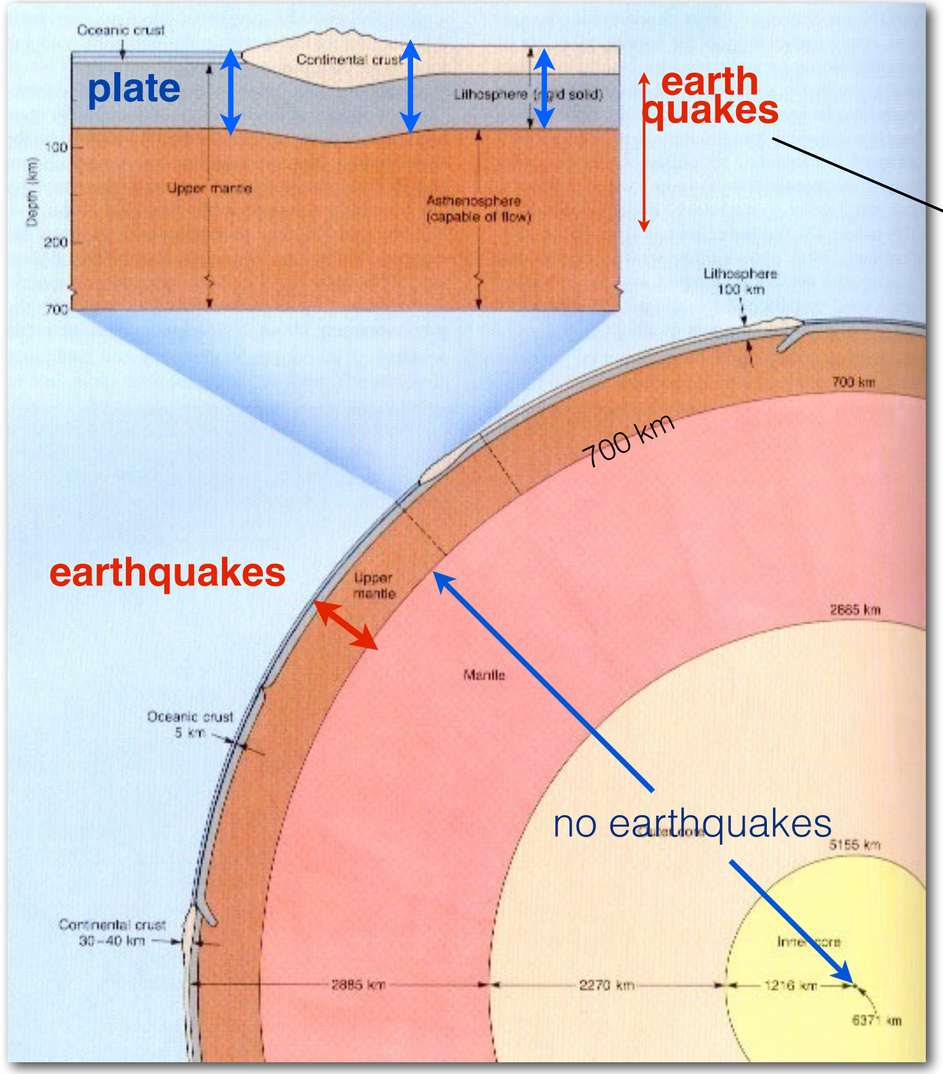
plate = crust + lithosphere

Shallow earthquakes: <70 km

Intermediate: >70 to 300 km

Deep: >300 km

Earthquakes occur within or between tectonic plates and within the upper mantle



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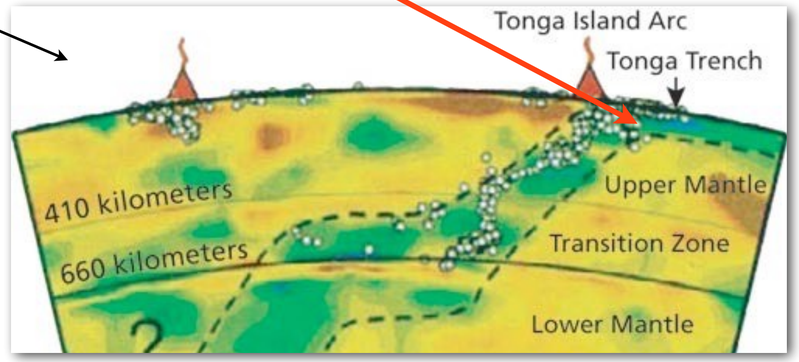
Samoa, September 29, 2009
focal depth 10 km



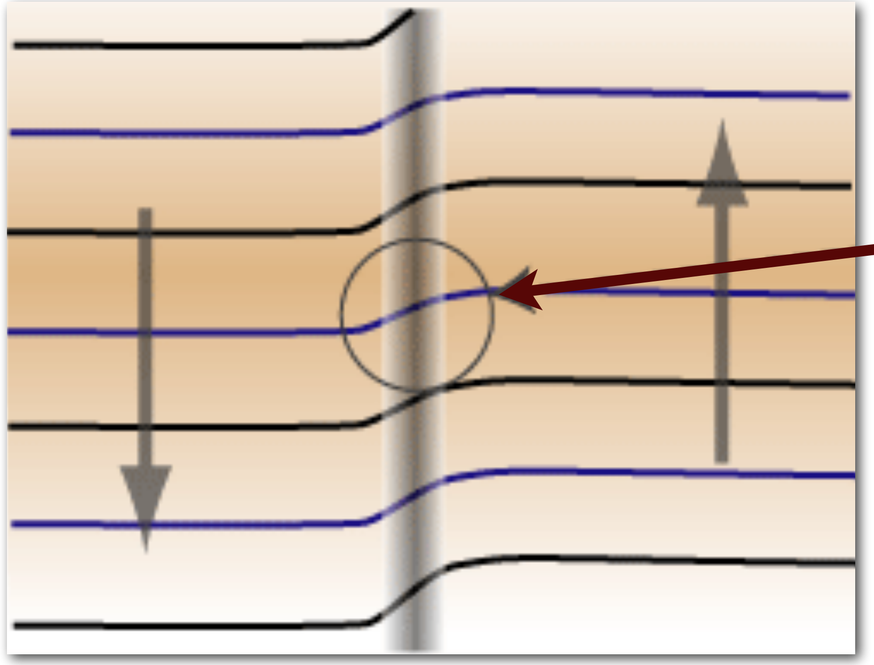
http://www.whoi.edu/cms/images/lstokey/2005/1/v42n2-detrick2en_5301.jpg

Each dot is a recorded earthquake in past 20 yrs

Causes of Earthquakes

Stage 1

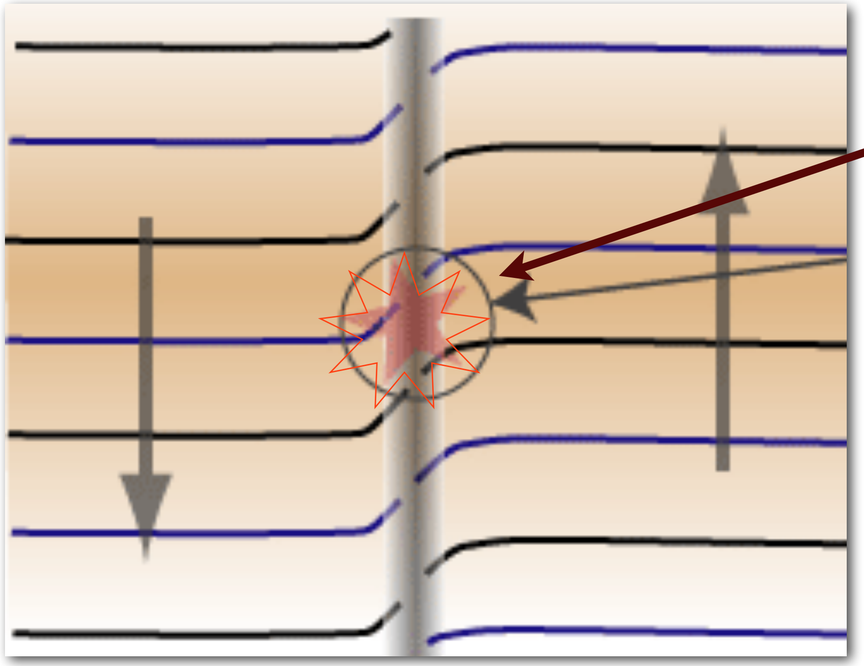
Most earthquakes occur
on ‘faults’ or fracture zones in the Earth’s crust
when crustal rocks are stretched
or slide past each other



rock bends a little (or a lot), but
doesn’t break,
yet...

folded rocks in Pyrenees, Spain

Stage 2



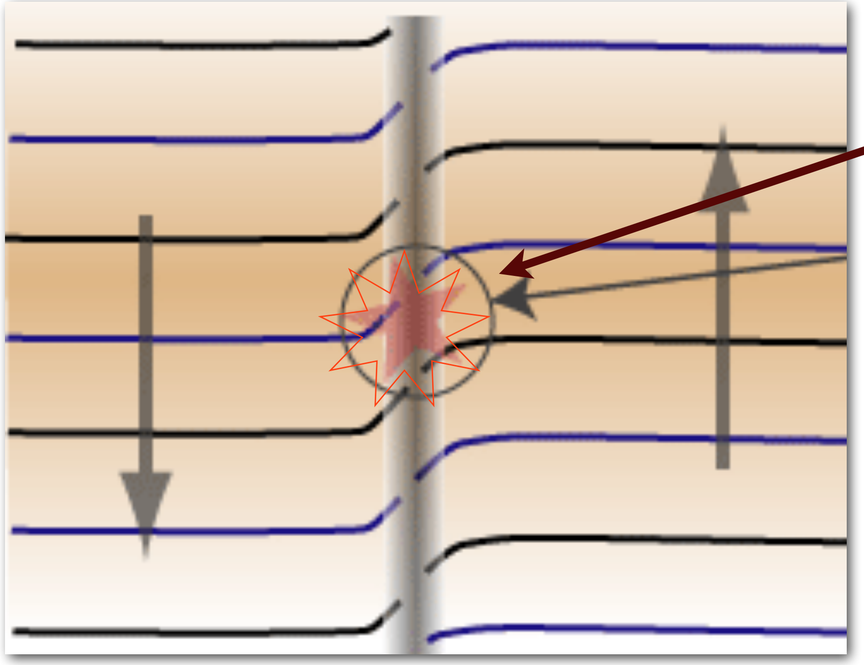
rock breaks...

fault in volcanic rocks
Kingman, AZ

and when it breaks, it releases a sudden pulse of energy....

this can be a very small ‘crack,’ or...

Stage 2



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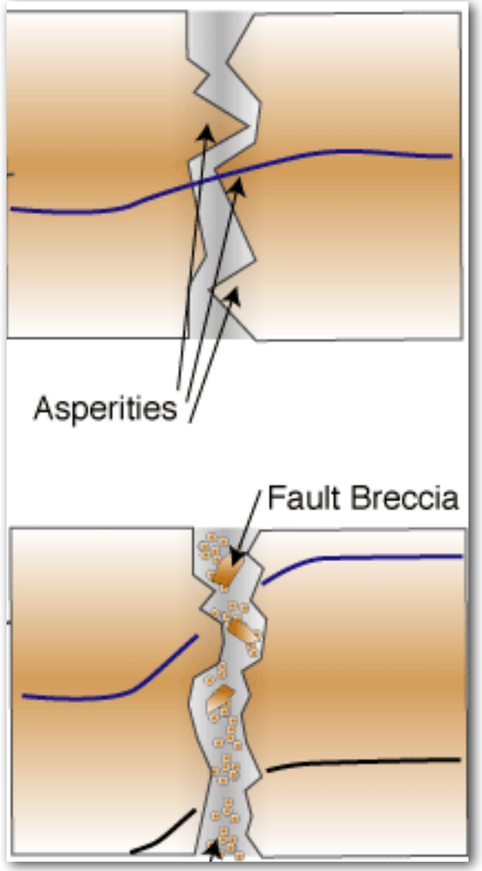
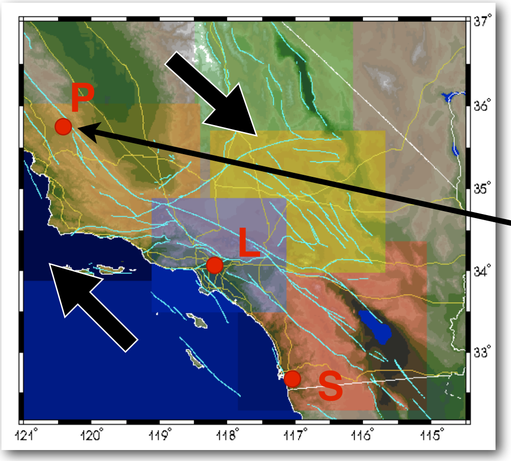
Causes of Earthquakes

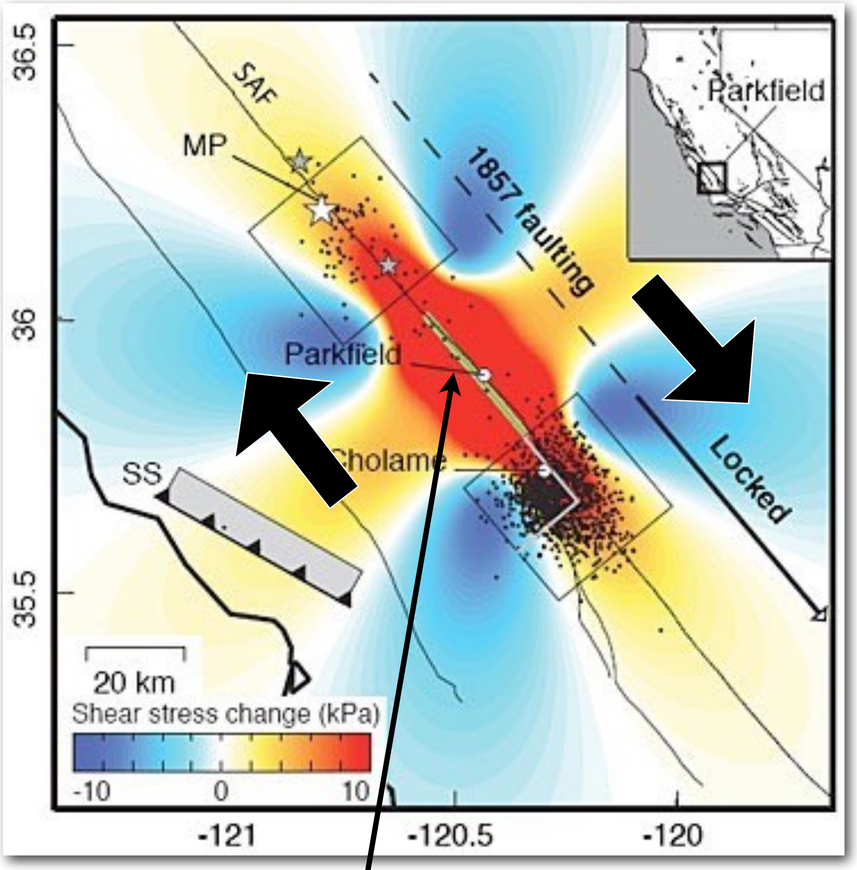
- faults ‘stick’ as they slide past one another
- friction (resistance to sliding) causes stress to build up at sticking point



can be small scale or large scale

San Andreas fault zone, southern CA





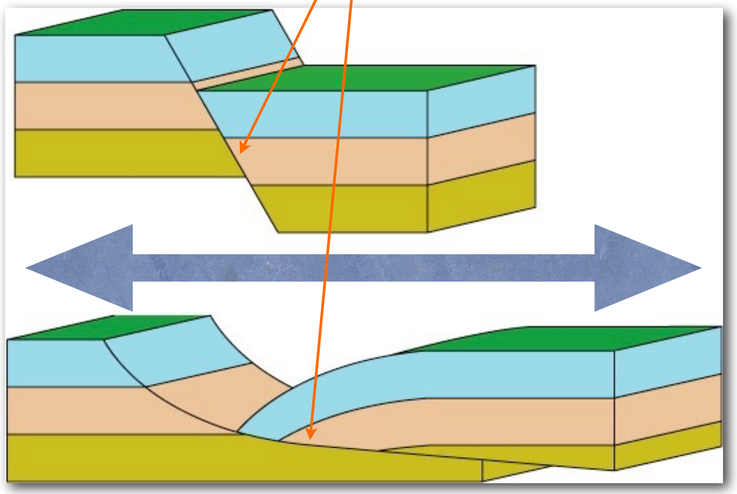
http://berkeley.edu/news/media/releases/2009/07/images/parkfield.jpg

stress build-up in locked section of fault

Causes of Earthquakes

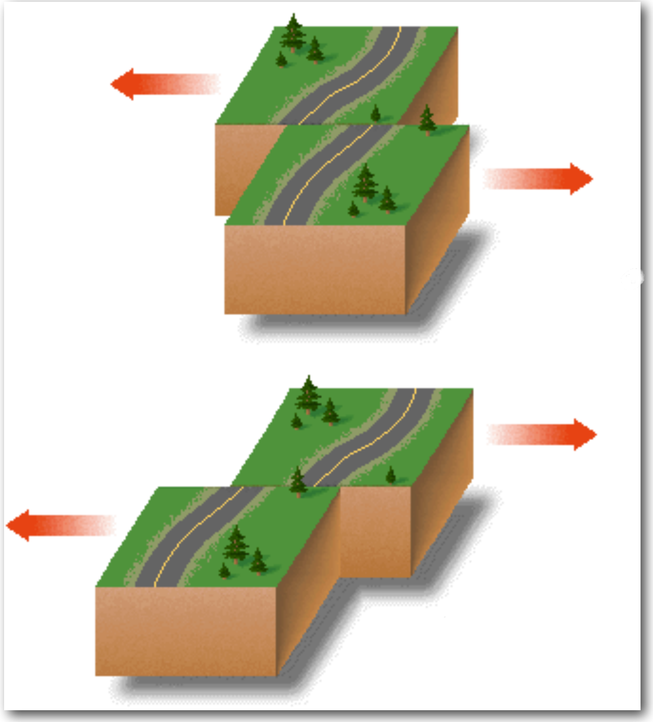
Most earthquakes occur
on ‘faults’ or fracture zones in the Earth’s crust
when crustal rocks are stretched

normal fault



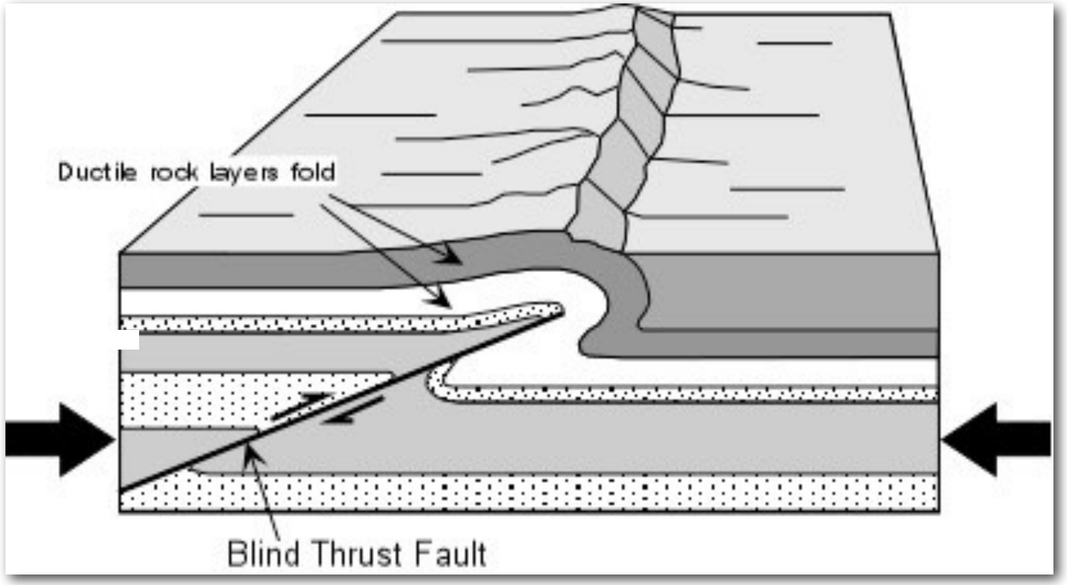
http://uanews.org/system/files/images/LowAngleNormalFault_GabrieleCasale.preview.jpg

... or slide past each other



http://www.scec.org/education/public/roots/pictures/strslipv.gif

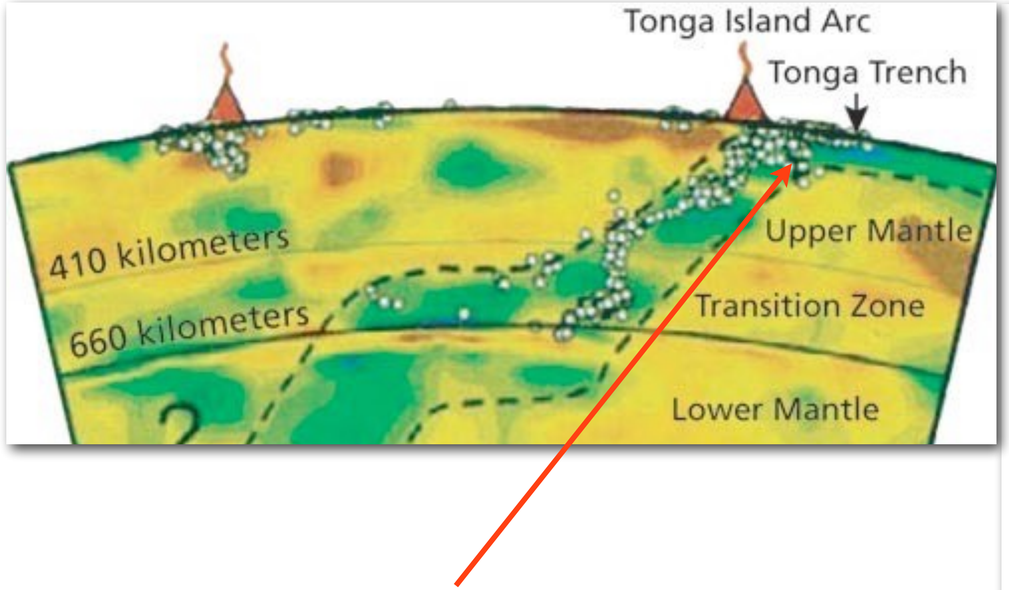
… or over each other



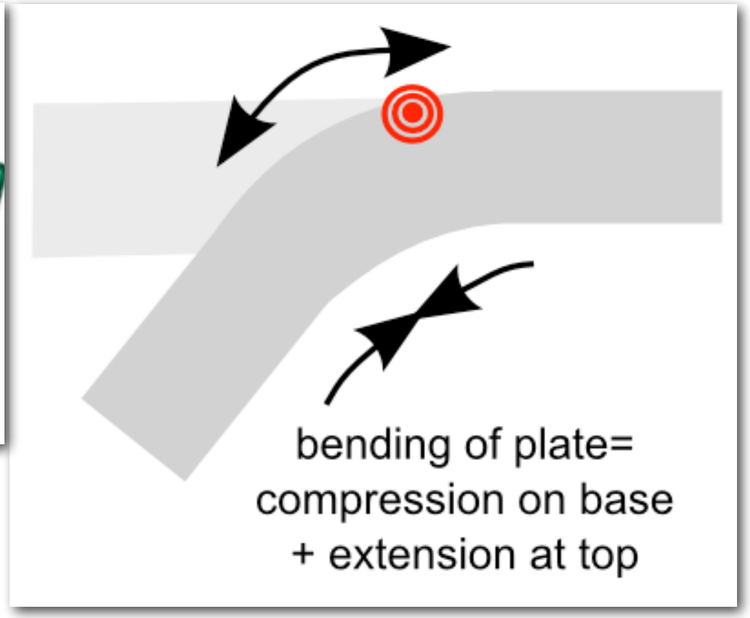
http://earthsci.org/processes/struct/equake1/blindyhrust.jpg

Causes of Earthquakes

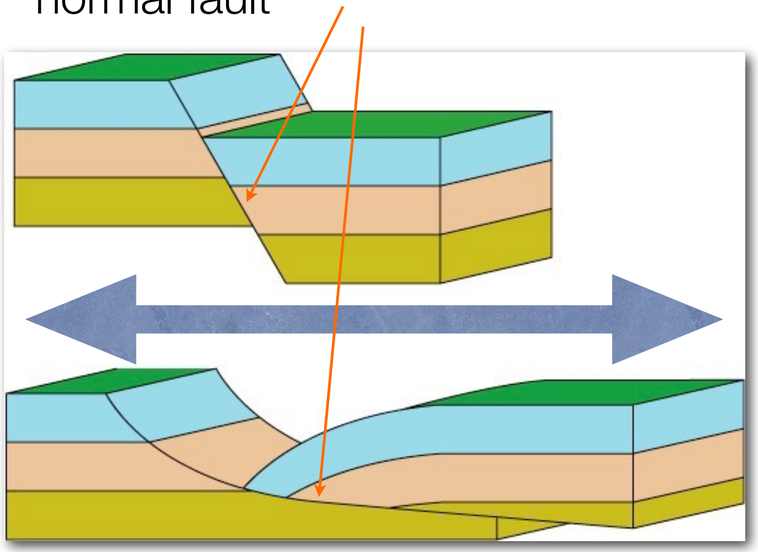
Three main types of ‘faults’ or fracture zones in the Earth’s crust:
(a) when crustal rocks are stretched



e.g., Samoa earthquake



normal fault



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Causes of Earthquakes

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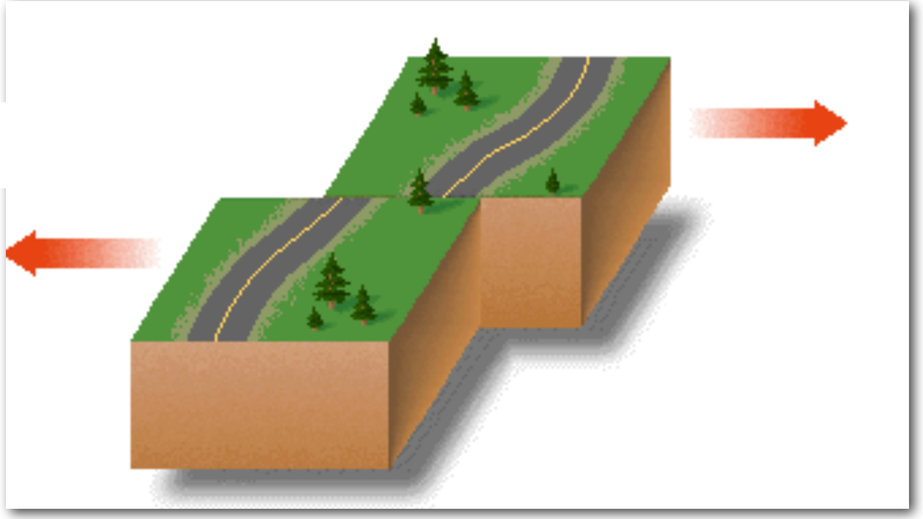
(a) when crustal rocks are stretched
(b) when they slide past each other



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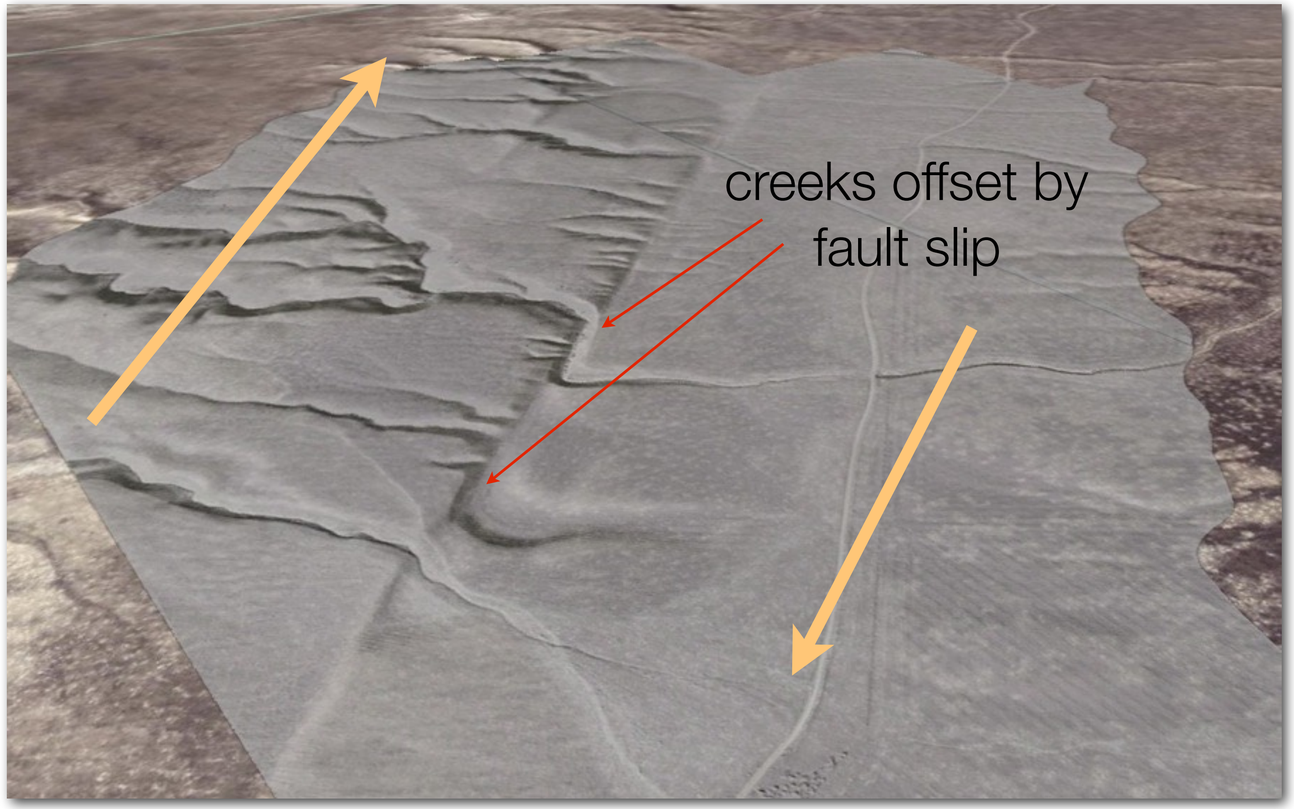
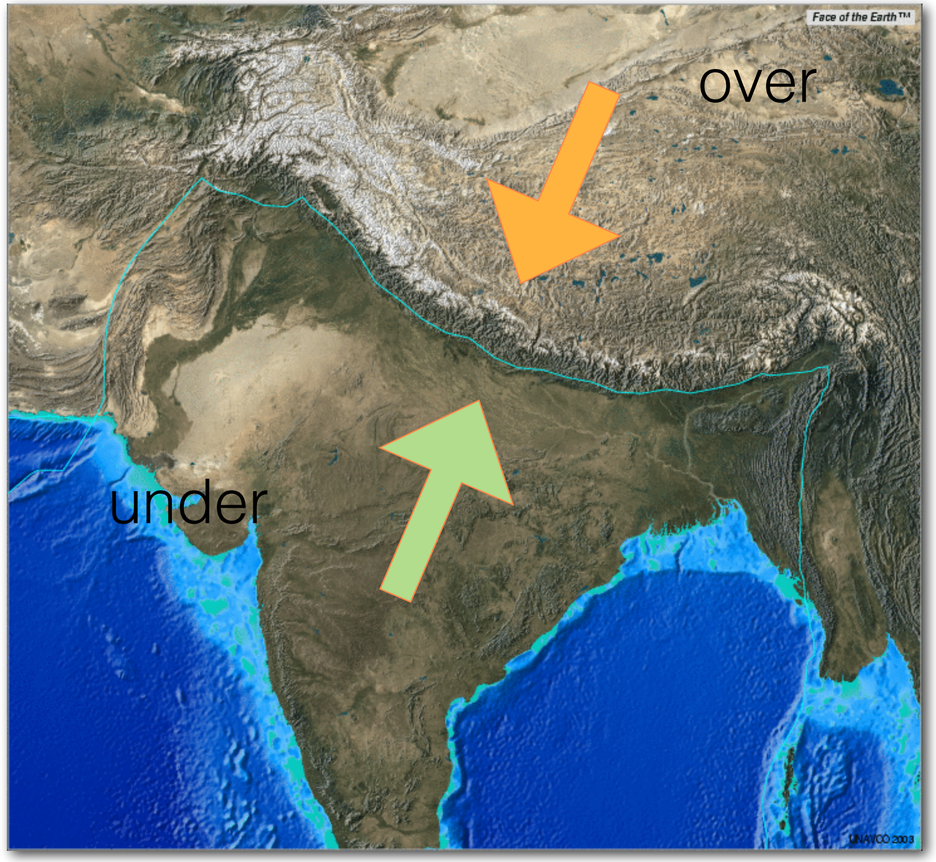
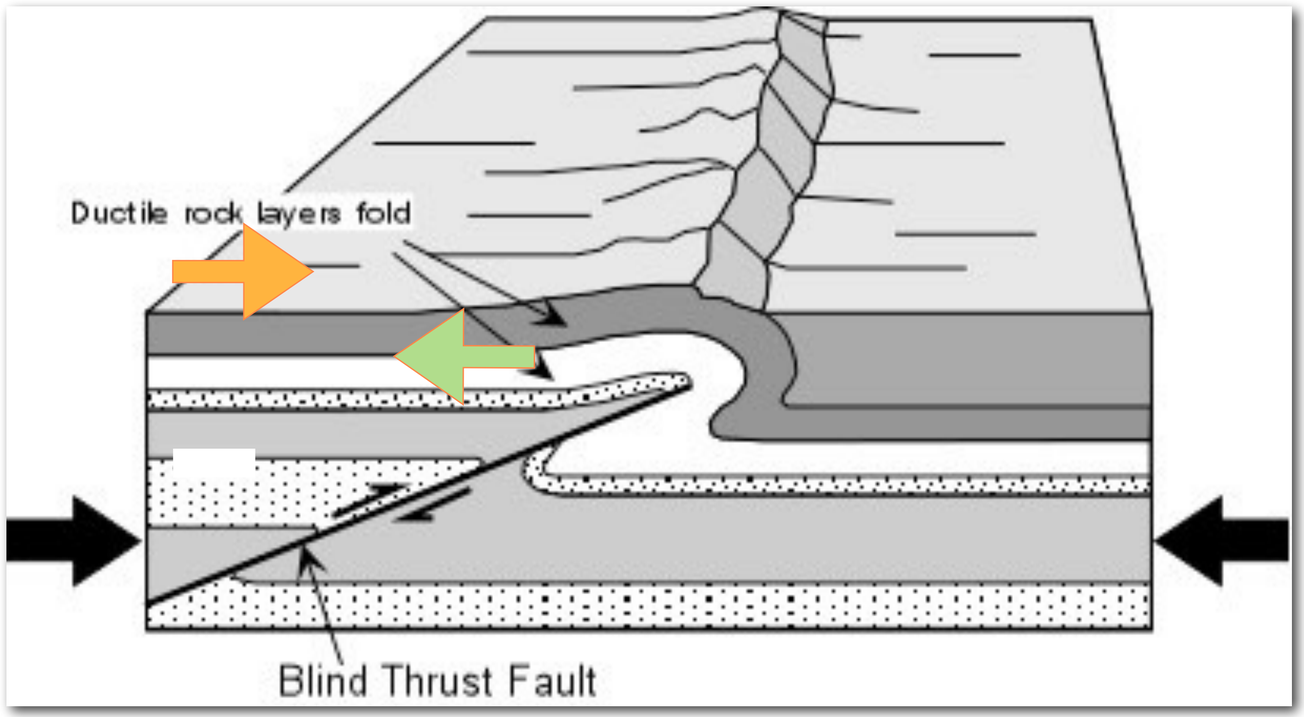


e.g., San Andreas fault zone
(aerial view looking S along fault)

Causes of Earthquakes

Three main types of ‘faults’ or fracture zones in the Earth’s crust:
(a) when crustal rocks are stretched
(b) when they slide past each other
(c) when they slide over each other





http://earthsci.org/processes/struct/equake1/blindyhrust.jpg

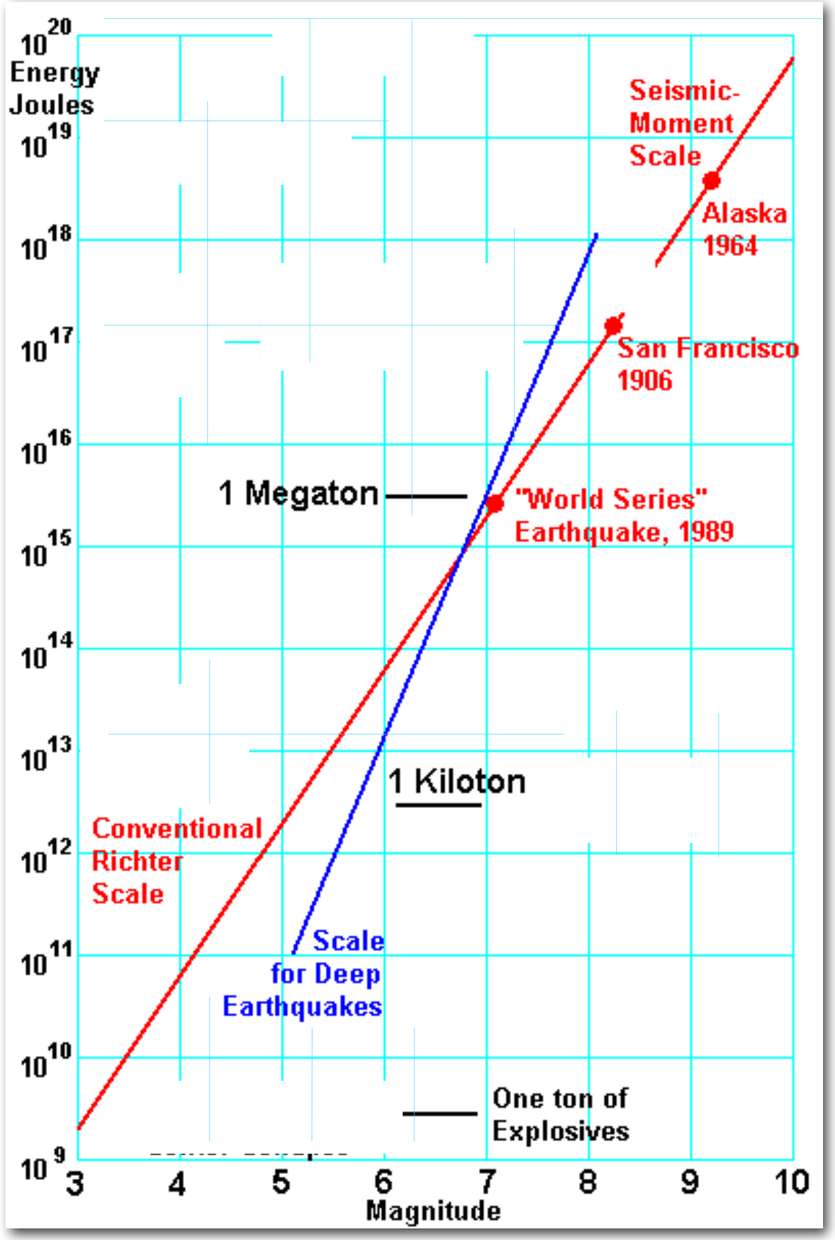
e.g., Alps-Zagros-Himalayan mountains

Magnitude of Earthquakes

Earthquake Moment Magnitude, M_W

- is measured on a logarithmic scale
- measures total amount of energy released (w = ‘work’)
- Seismic moment = area x displacement of fault rupture

Note: ‘Richter Scale’ is similar, and also logarithmic, but not as accurate



http://www.uwgb.edu/DutchS/Graphics-Geol/SEISMOL/MagScale0.gif

Magnitude of Earthquakes

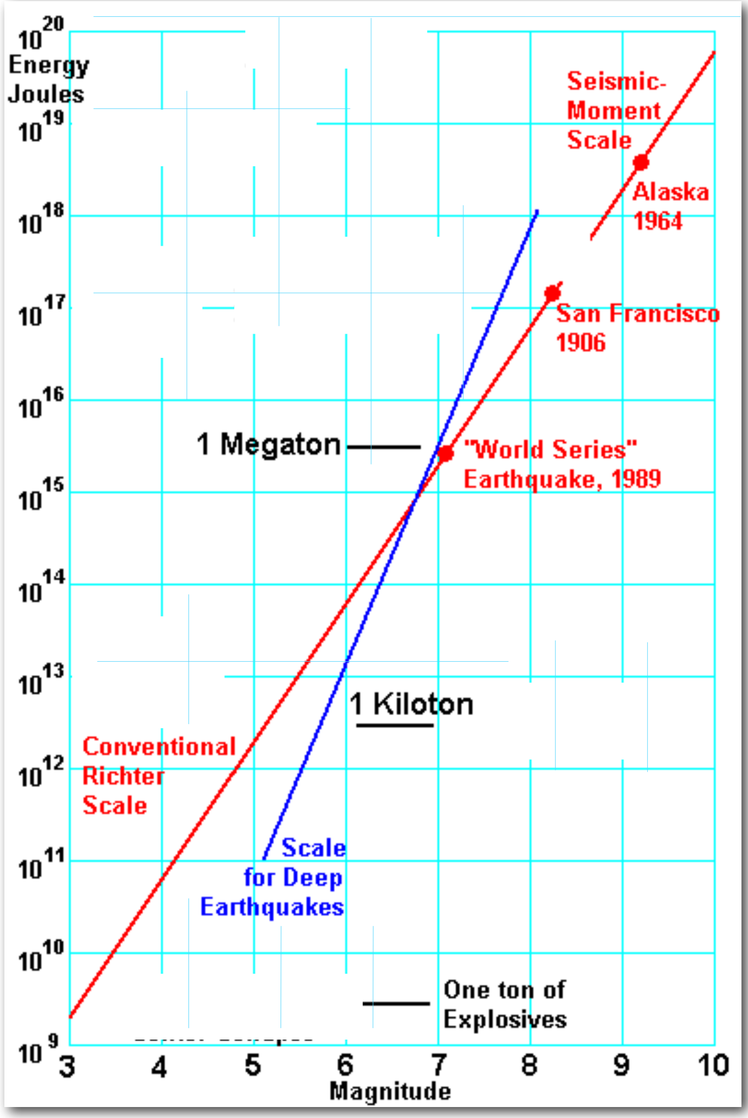
Magnitude:
a number that characterizes the relative size of an earthquake. based on measurement of the maximum motion recorded by a seismograph.

Several scales; most commonly used are:
(1) local magnitude (ML), commonly referred to as "Richter magnitude",
(2) surface-wave magnitude (Ms),
(3) body-wave magnitude (Mb), and
(4) moment magnitude (Mw).

Scales 1-3 have limited range and applicability and do not satisfactorily measure the size of the largest earthquakes.

Earthquake Moment Magnitude, M_W

- is uniformly applicable to all sizes of earthquakes but is more difficult to compute than the other types
- based on the concept of
  seismic moment = area x displacement of fault rupture
- measured on a logarithmic scale
- measures total amount of energy released (w = ‘work’)



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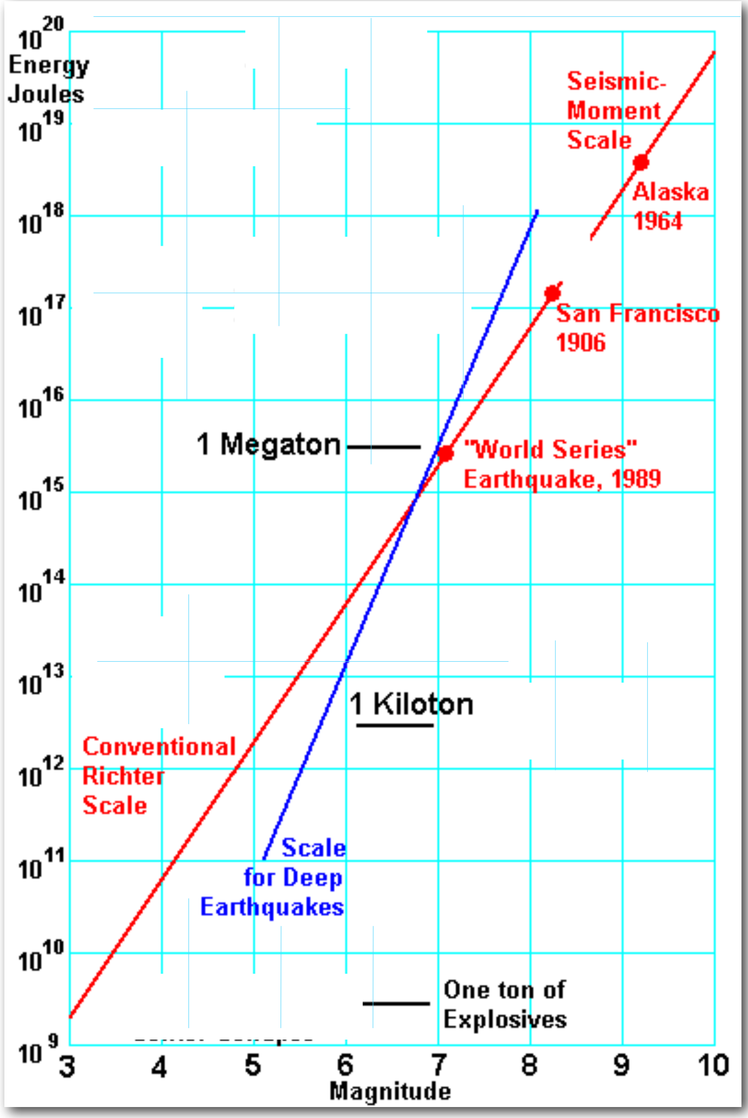
(4) moment magnitude (M_w).

Scales 1-3 have limited range and applicability and do not satisfactorily measure the size of the largest earthquakes.

The moment magnitude M_w is a dimensionless value defined by Kanamori (1977) as

$$M_{\mathrm{w}} = \frac{2}{3}\log_{10}(M_0) - 10.7,$$

where M_0 is the seismic moment in dyne·cm (10^{-7} N·m). The constant values in the equation are chosen to achieve consistency with the magnitude values produced by earlier scales.



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Kanamori, H., 1977, The energy release of great earthquakes, *J Geophys Res*, **82,** 2981–2987.

Magnitude of Earthquakes

MAGNITUDE M_W	IMPACT	FREQUENCY
2.5 or less	Usually not felt; recorded by seismographs	900,000 per year
2.5 to 5.4	Often felt; minor damage	10,000 per year
5.5 to 6.0	Slight structural damage	500 per year
6.1 to 6.9	Significant structural damage	100 per year
7.0 to 7.9	Major earthquake; serious damage	20 per year
8.0 or greater	Great earthquake; extremely destructive	0.2 per year

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http://geoinfo.nmt.edu/publications/periodicals/litegeology/images/dogquake_small.gif

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Note:
Impact depends strongly on the depth of the earthquake, also the mechanism

20 largest earthquakes recorded

	Mag	Location	Date (UTC)	Time (UTC)	Latitude	Longitude
1.	9.5	ChileValdivia Earthquake	1960-05-22	19:11	38.14°S	73.41°W
2.	9.2	Great Alaska Earthquake	1964-03-28	03:36	60.91°N	147.34°W
3.	9.1	Sumatra-Andaman Islands Earthquake	2004-12-26	00:58	3.30°N	95.98°E
4.	9.1	Tohoku Earthquake	2011-03-11	05:46	38.30°N	142.37°E
5.	9.0	Kamchatka, Russia	1952-11-04	16:58	52.62°N	159.78°E
6.	8.8	ChileMaule Earthquake	2010-02-27	06:34	36.12°S	72.90°W
7.	8.8	1906 Ecuador—Colombia Earthquake	1906-01-31	15:36	0.96°N	79.37°W
8.	8.7	Rat Islands Earthquake	1965-02-04	05:01	51.25°N	178.72°E
9.	8.6	Assam, Tibet	1950-08-15	14:09	28.36°N	96.45°E
10.	8.6	off West Coast of Northern Sumatra	2012-04-11	08:39	2.33°N	93.06°E
11.	8.6	Indonesia Nias Earthquake	2005-03-28	16:10	2.09°N	97.11°E
12.	8.6	Andreanof Islands, Alaska	1957-03-09	14:23	51.50°N	175.63°W
13.	8.6	Unimak Island Earthquake, Alaska	1946-04-01	12:29	53.49°N	162.83°W
14.	8.5	Banda Sea	1938-02-01	19:04	5.05°S	131.61°E
15.	8.5	Atacama, Chile	1922-11-11	04:33	28.29°S	69.85°W
16.	8.5	Kuril Islands	1963-10-13	05:18	44.87°N	149.48°E
17.	8.4	Kamchatka, Russia	1923-02-03	16:02	54.49°N	160.47°E
18.	8.4	Southern Sumatra, Indonesia	2007-09-12	11:10	4.44°S	101.37°E
19.	8.4	Peru Earthquake	2001-06-23	20:33	16.27°S	73.64°W
20.	8.4	JapanSanriku Japan	1933-03-02	17:31	39.21°N	144.59°E

Some important earthquakes in recent years

Tangshan, China 1976	M_W 7.8	240,000 killed
Sumatra, 2004	M_W 9.1	>250,000 killed *
Haiti, 2010	M_W 7.0	>80,000 killed
Sichuan, China 2008	M_W 7.9	>69,000 killed
Manjil, Iran 1990	M_W 7.7	>40,000 killed
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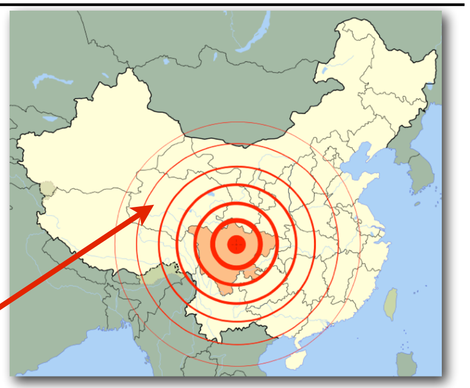
Northridge, CA 1994	M_W 6.7	72 killed



http://noeljenkins.files.wordpress.com/2007/01/bam_ir2726.JPG

http://www.iranmap.com/images/cities/bamafter.jpg

Magnitude of Earthquakes

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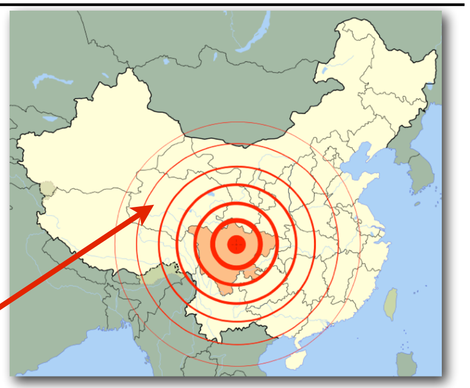

http://noeljenkins.files.wordpress.com/2007/01/bam_ir2726.JPG

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Why the big range in casualties?

Magnitude of Earthquakes

Intensity:

A number describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. Several scales exist, but the ones most commonly used in the United States are

- Modified Mercalli scale and the
- Rossi-Forel scale.

Intensity for a specific earthquake depends on location, unlike the magnitude, which is one number for each earthquake.

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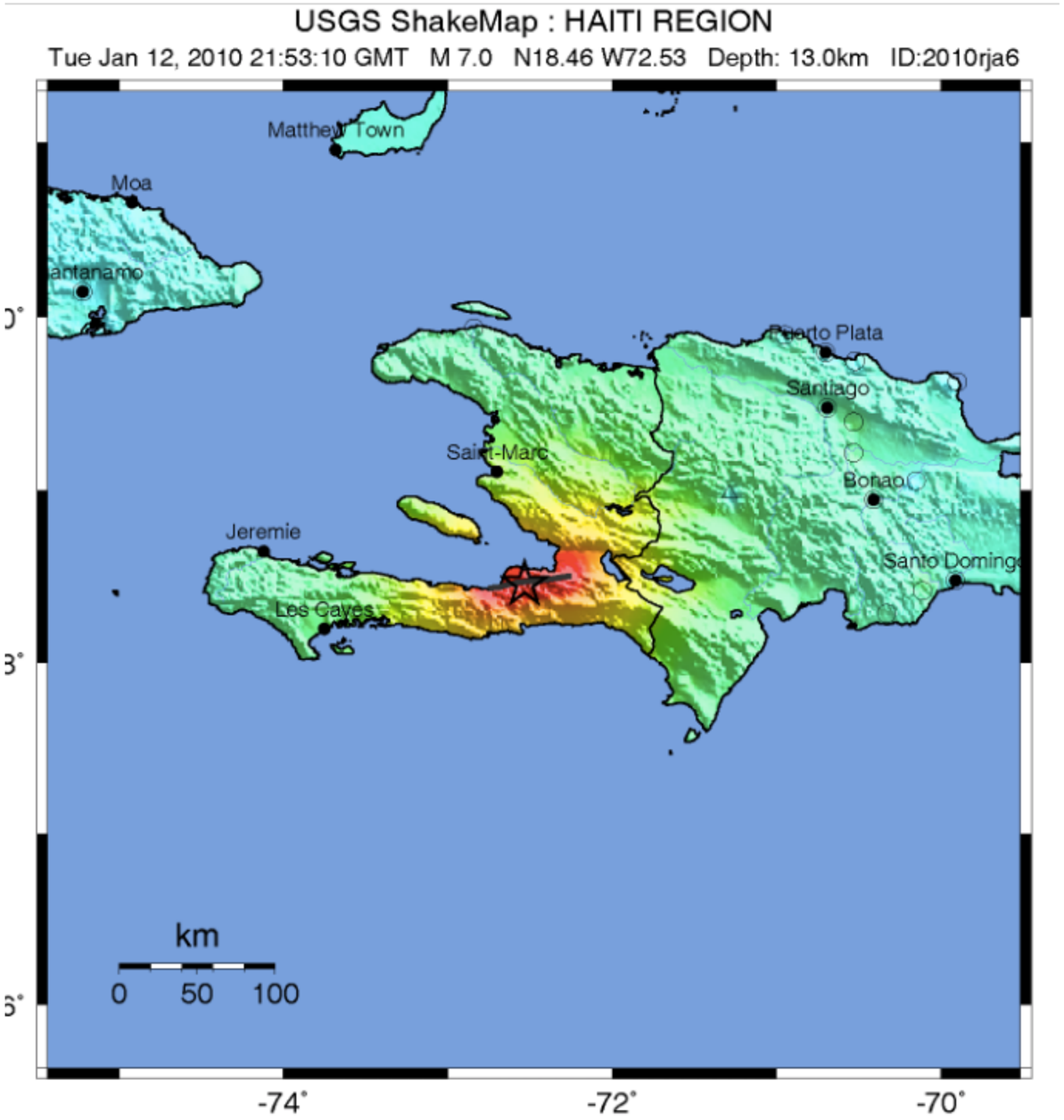
I. Not felt	Not felt except by very few under especially favorable conditions.
II. Weak	Felt only by a few people at rest, especially on upper floors of buildings.
III. Weak	Felt quite noticeably by people indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV. Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V. Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI. Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII. Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII. Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX. Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Liquefaction.
X. Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI. Extreme	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII. Extreme	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

Magnitude of Earthquakes

12 January 2010, Mw = 7.0, Depth: 13 km

Map Version 7 Processed Wed Jan 13, 2010 06:53:11 PM MST -- NOT REVIEWED BY HUMAN

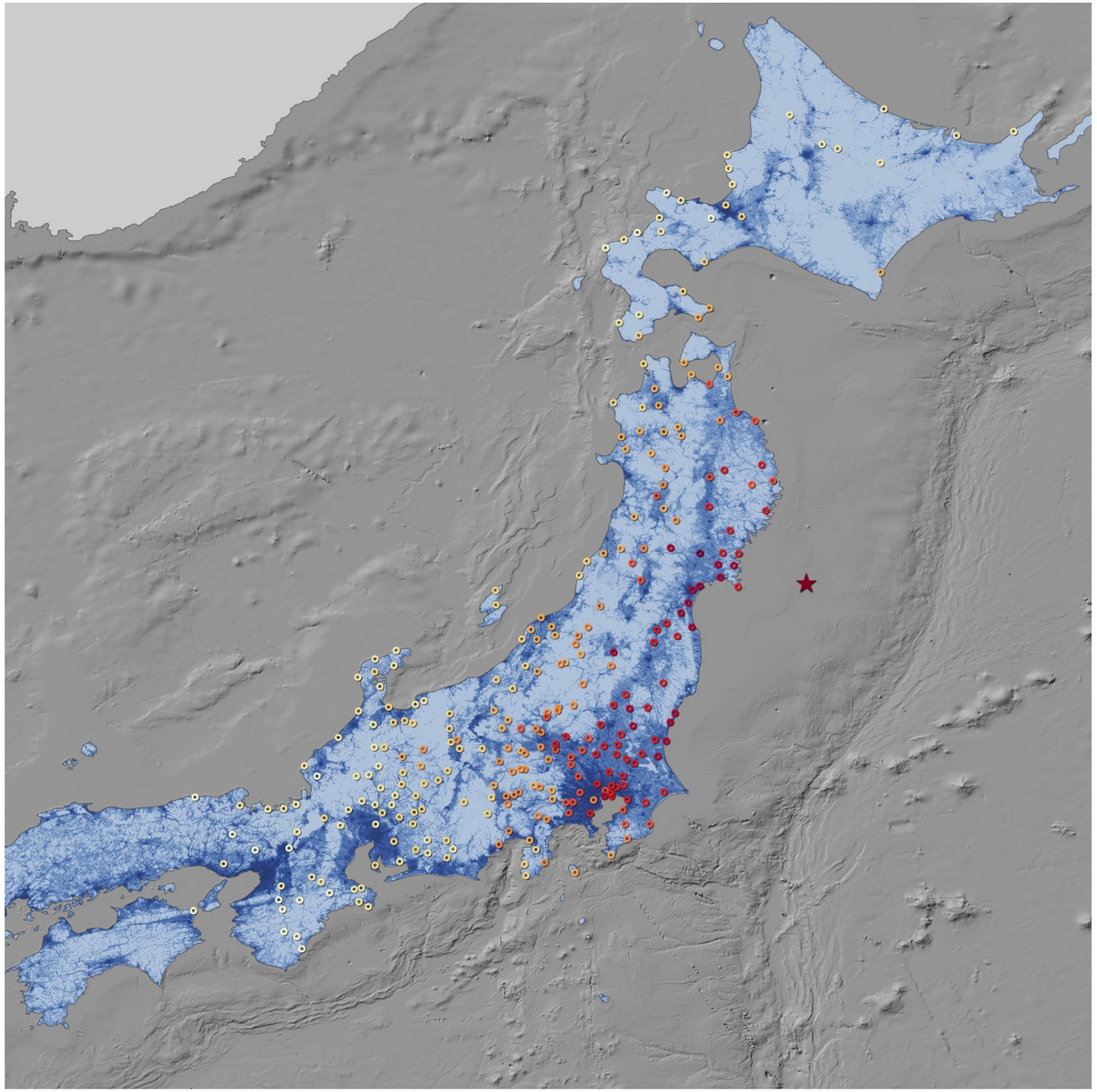
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

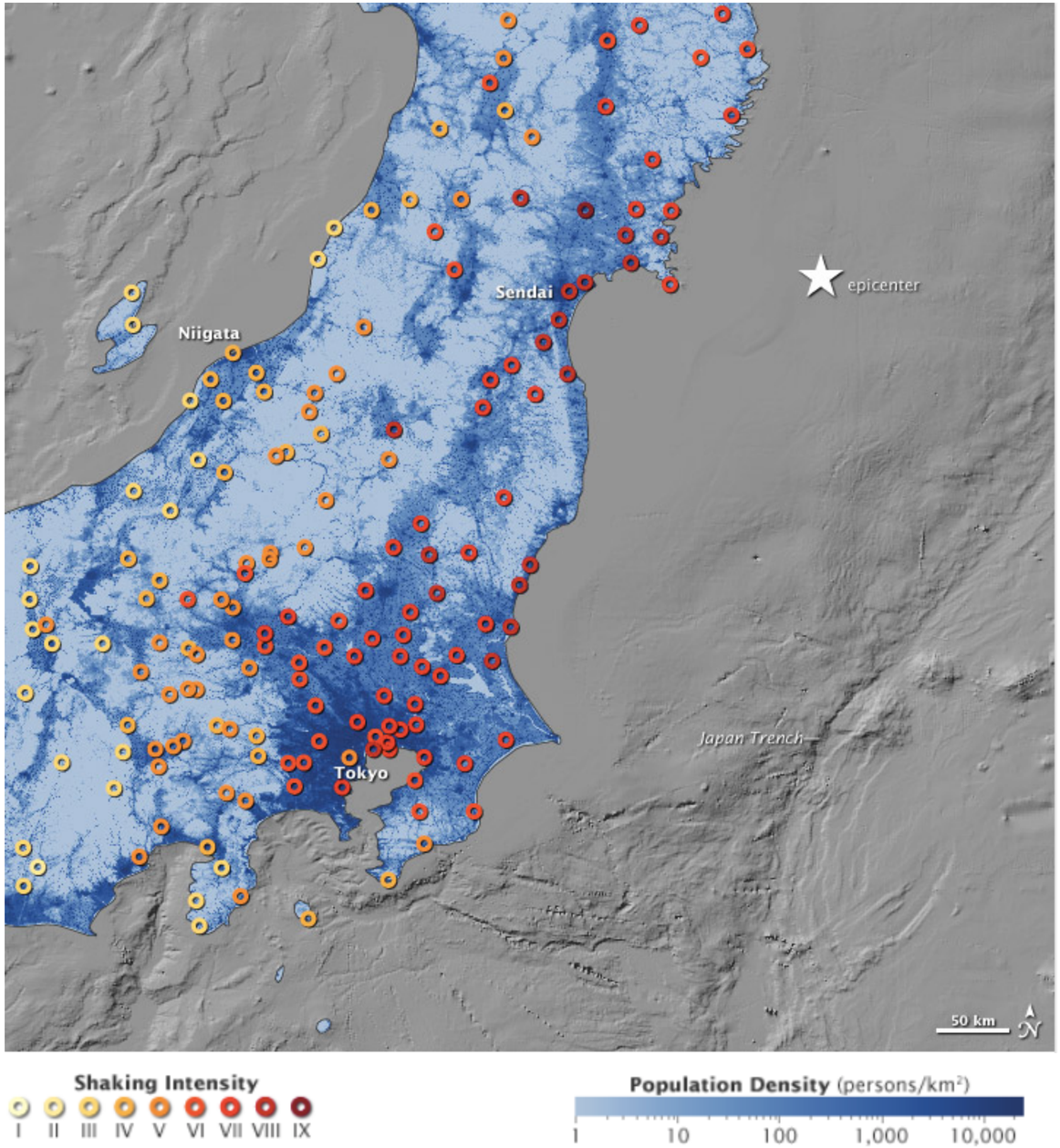


Map Version 7 Processed Wed Jan 13, 2010 06:53:11 PM MST -- NOT REVIEWED BY HUMAN

Magnitude of Earthquakes

11 March 2011, Mw = 9.0-9.1, Depth: 29 km





Ground Shaking

Earthquake energy (seismic energy) is released as a wave through the rock

http://earthquake.usgs.gov/learning/faq/images/psdiag.jpg

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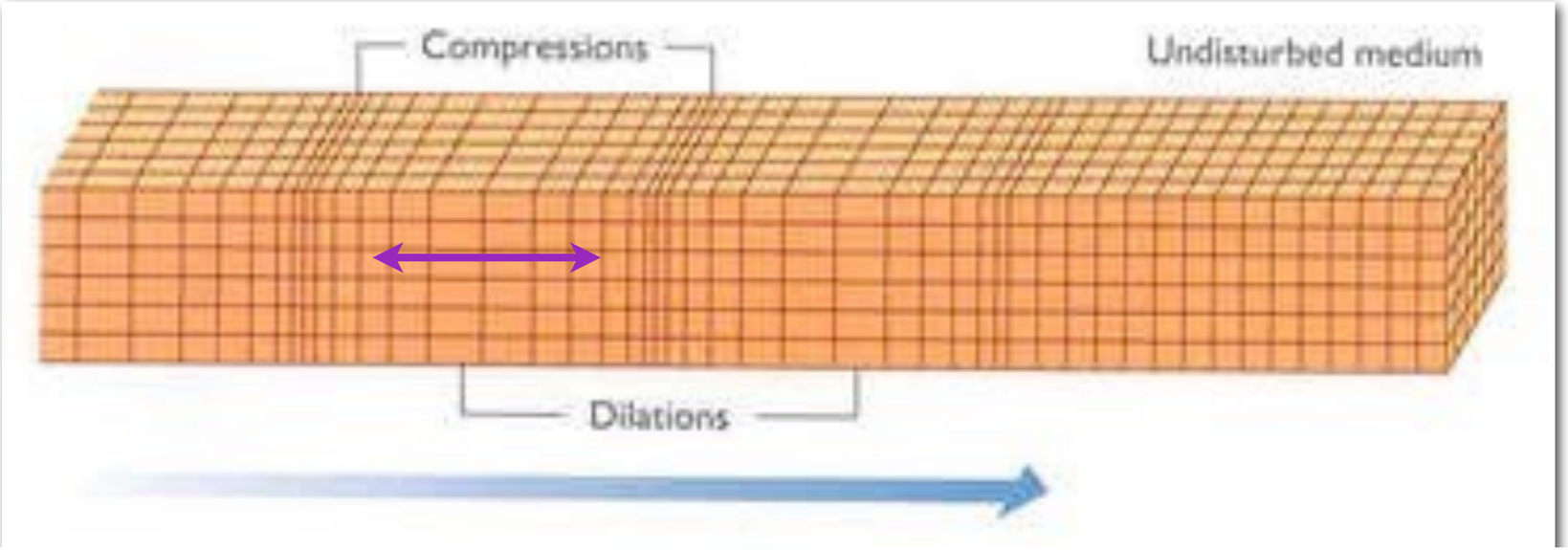

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Two components to the wave:

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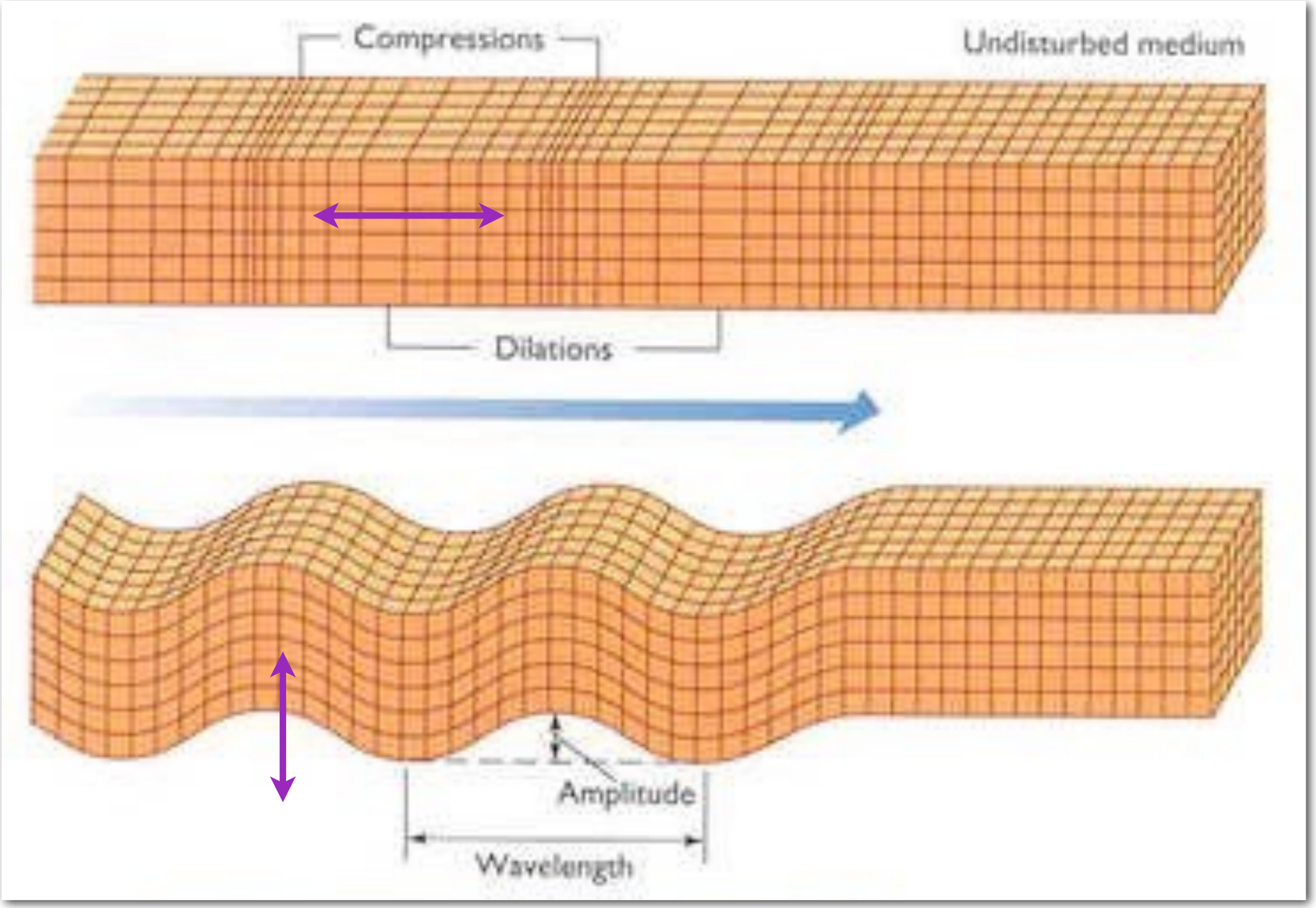
Shear, S wave



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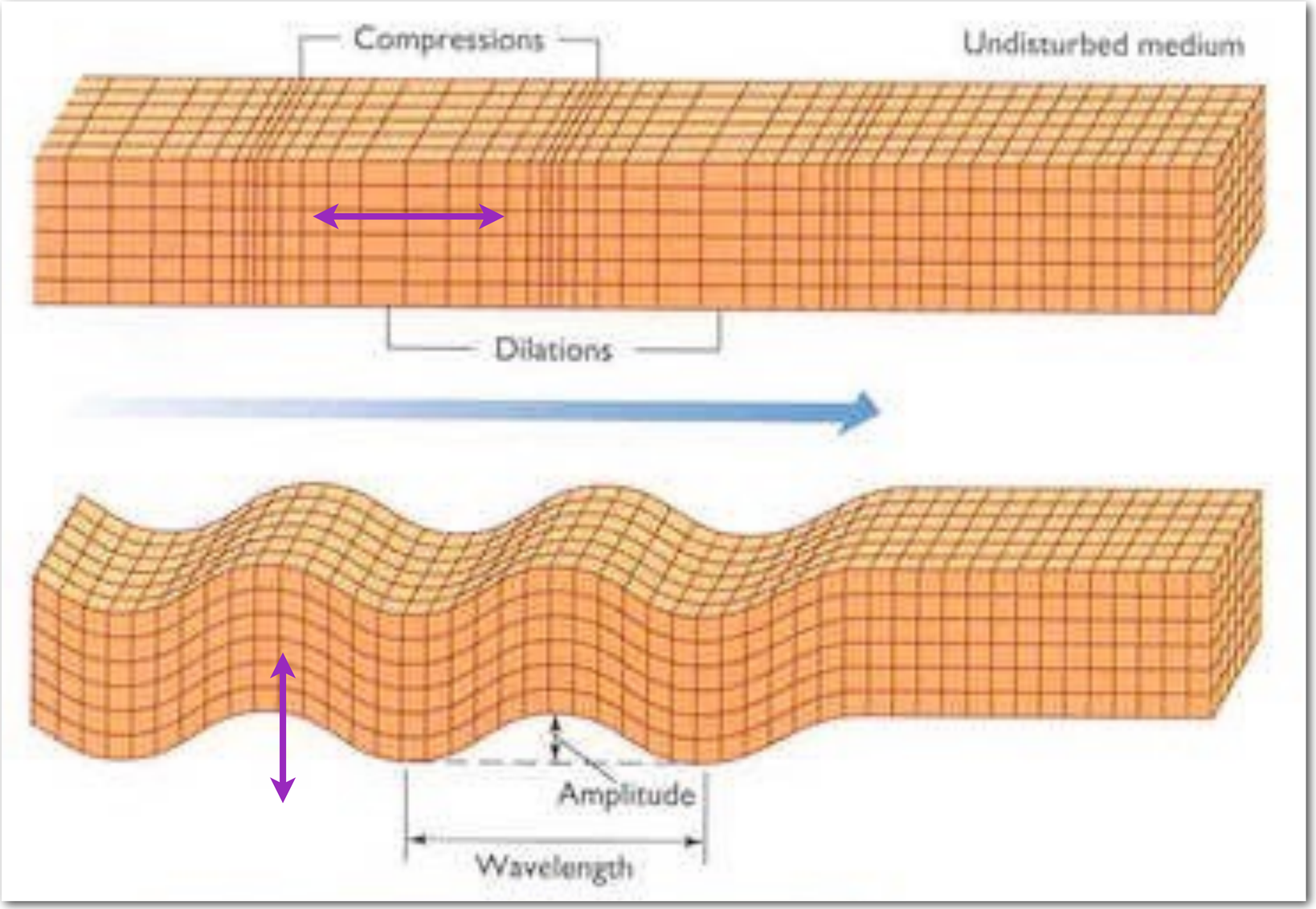
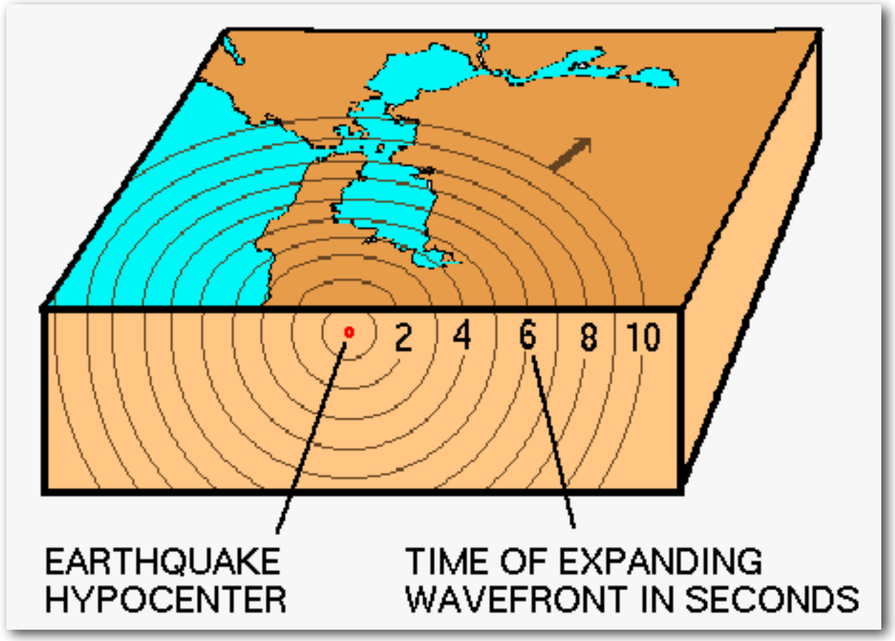
P waves and S waves have different velocities



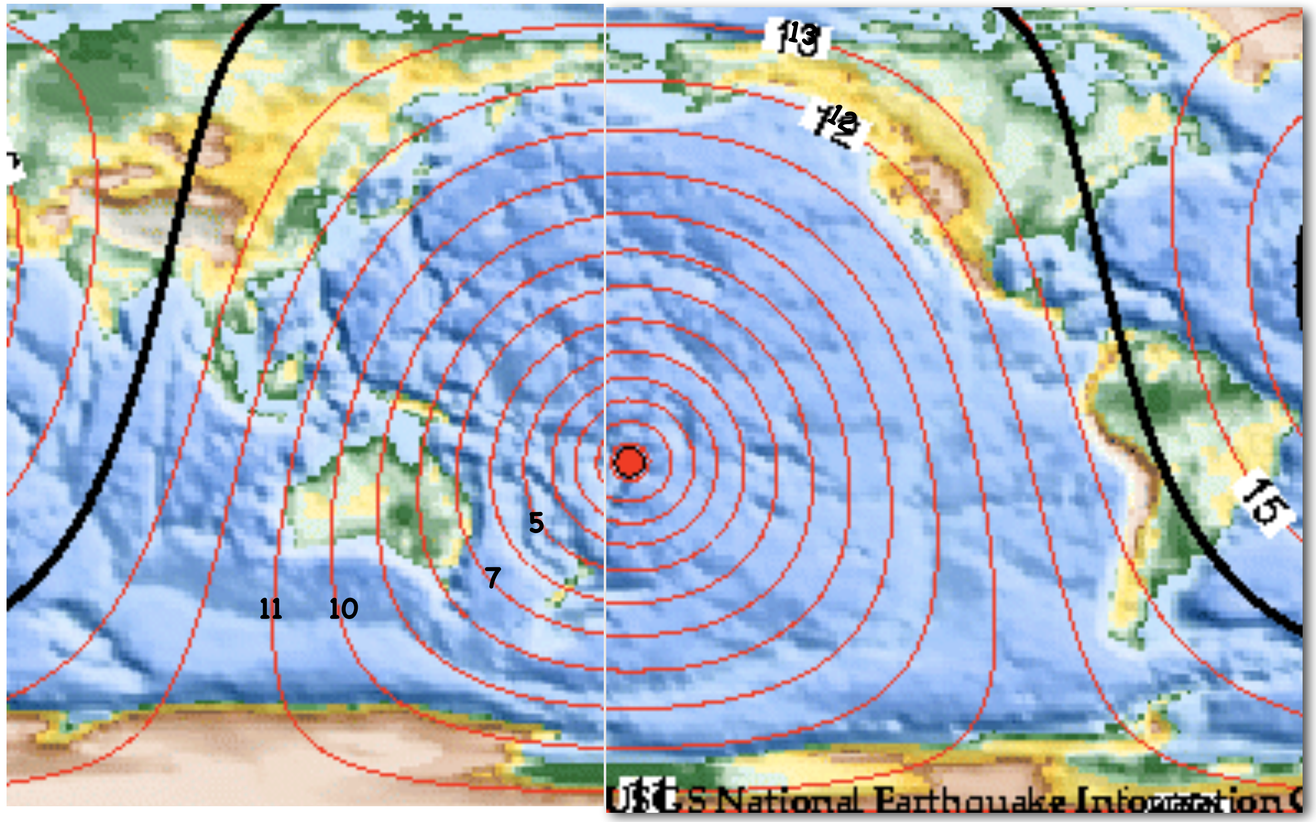
http://earthquake.usgs.gov/learning/faq/images/psdiag.jpg

Ground Shaking



http://earthquake.usgs.gov/learning/faq/images/blockwave.gif

Seismic energy wavefront expands rapidly outward in all directions

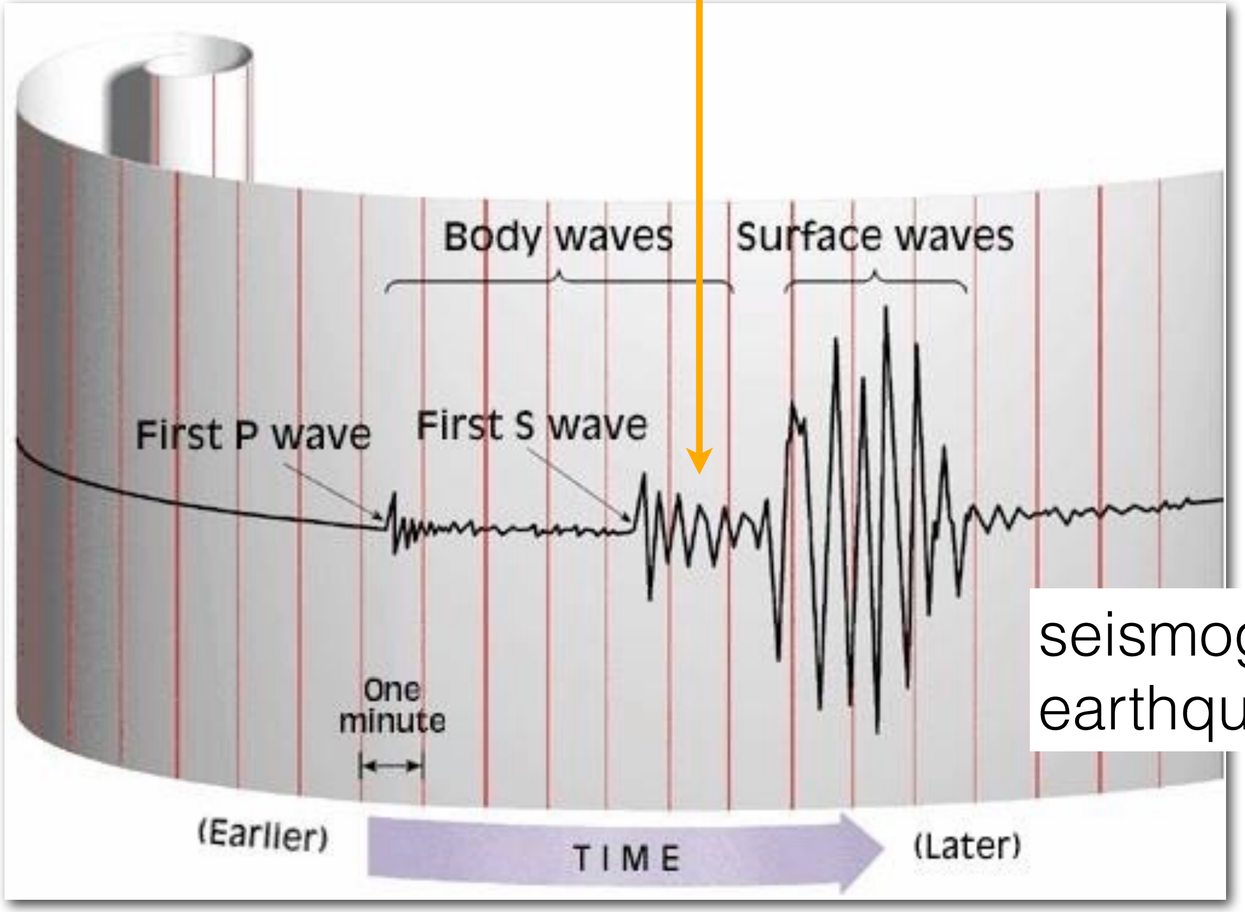


P wave travel times (in minutes) for Samoa earthquake of 09/29/09

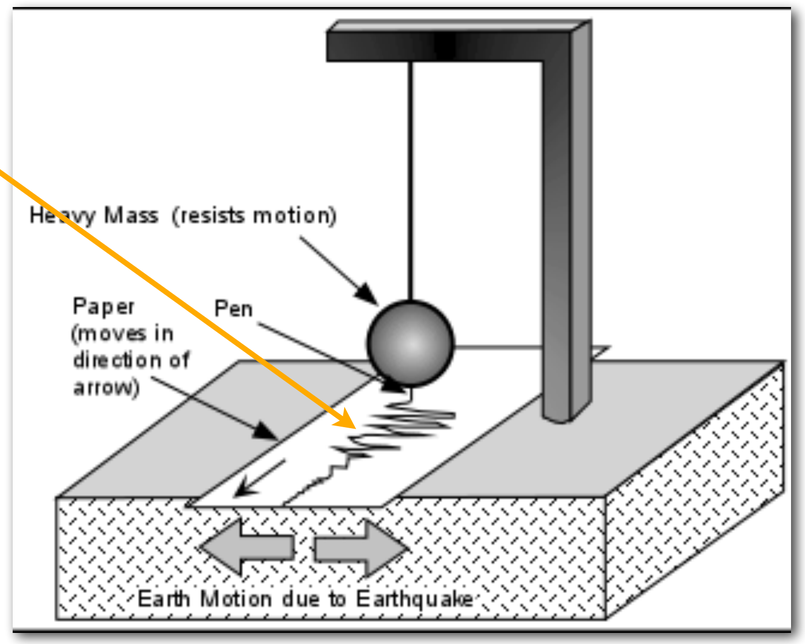
Ground Shaking

Seismograms (drawings made by seismometers)

Record arrival of P and S waves



http://www.showme.net/~fkeller/quake/images2/pwave2.jpg



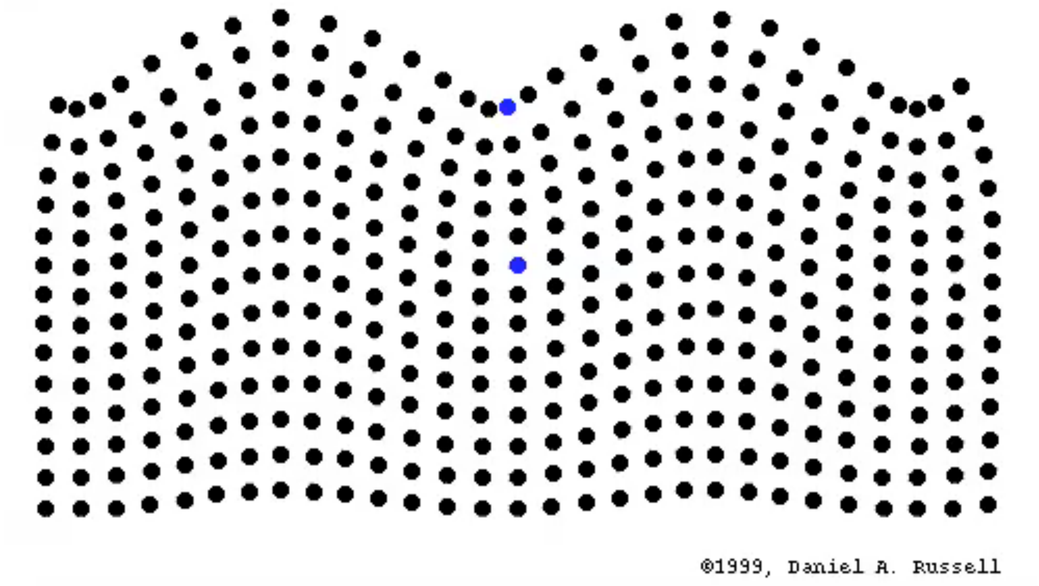
http://www.tulane.edu/~sanelson/images/seismograph.gif

seismogram of a distant earthquake

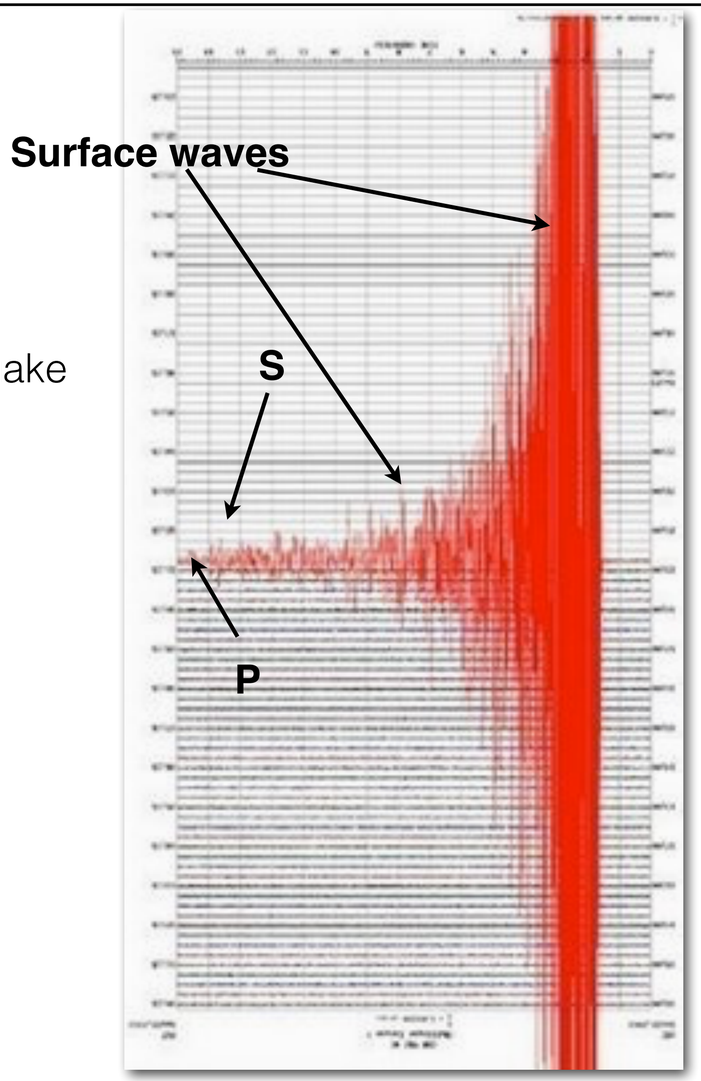
P waves travel fastest, arrive first!

Magnitude of Earthquakes

It's the Surface Waves that cause groundshaking and do the most damage!



seismograph for Samoa earthquake
09/29/09



http://news.yahoo.com/nphotos/Samoa-seismograph/photo//090929/photos_wl_pc_afp/e4b3a34480d36b1fb185a36b299d6d13//s:/afp/20090929/wl_asia_afp/samoaquake

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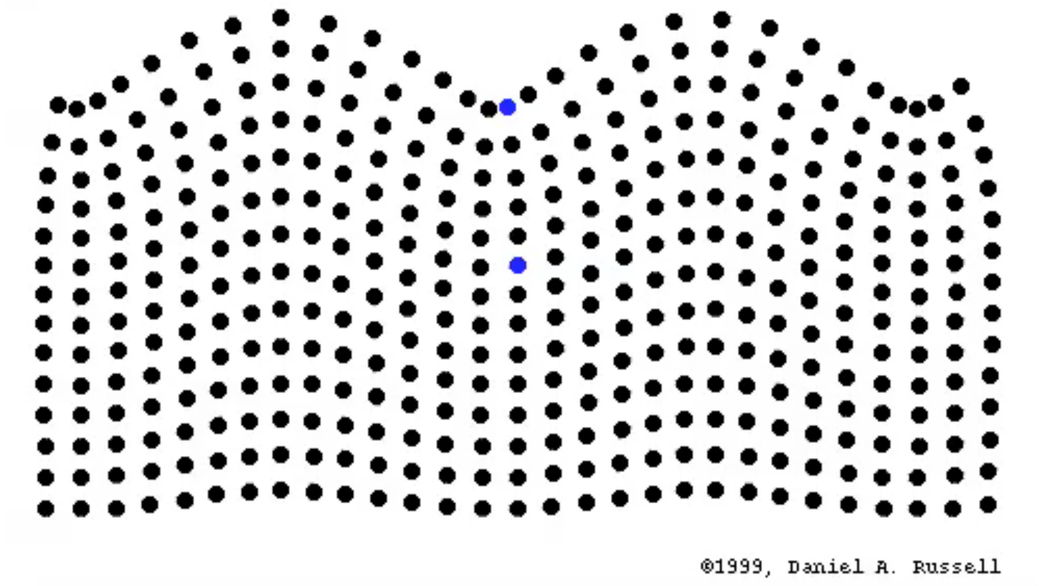

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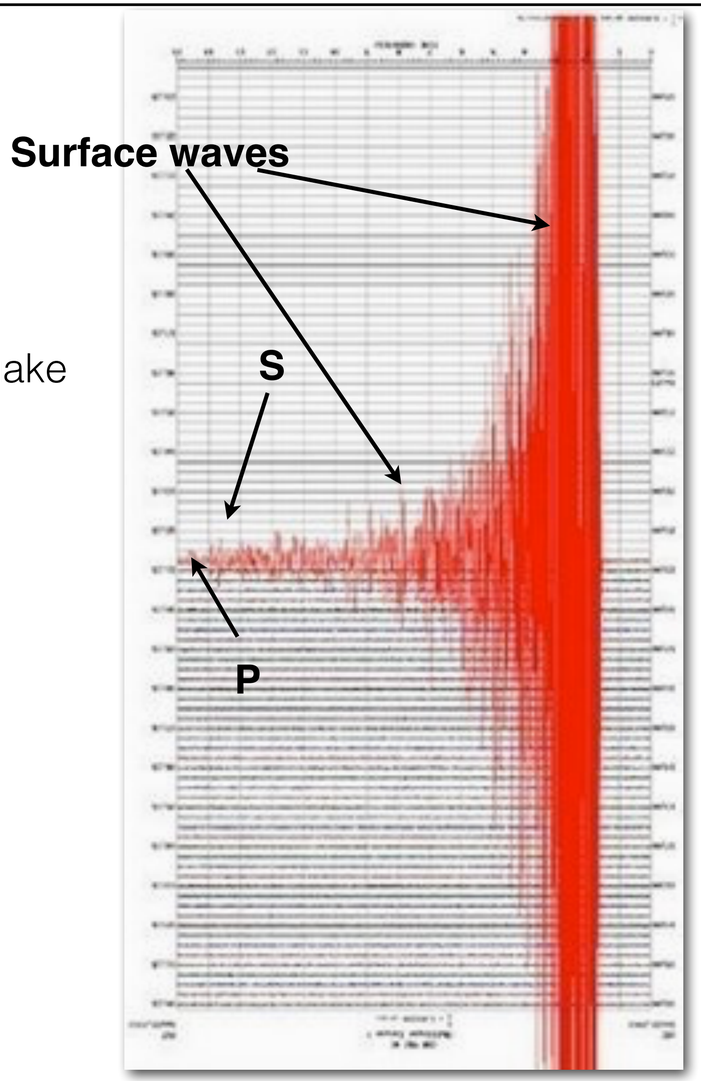


http://news.yahoo.com/nphotos/Samoa-seismograph/photo//090929/photos_wl_pc_afp/e4b3a34480d36b1fb185a36b299d6d13//s:/afp/20090929/wl_asia_afp/samoaquake

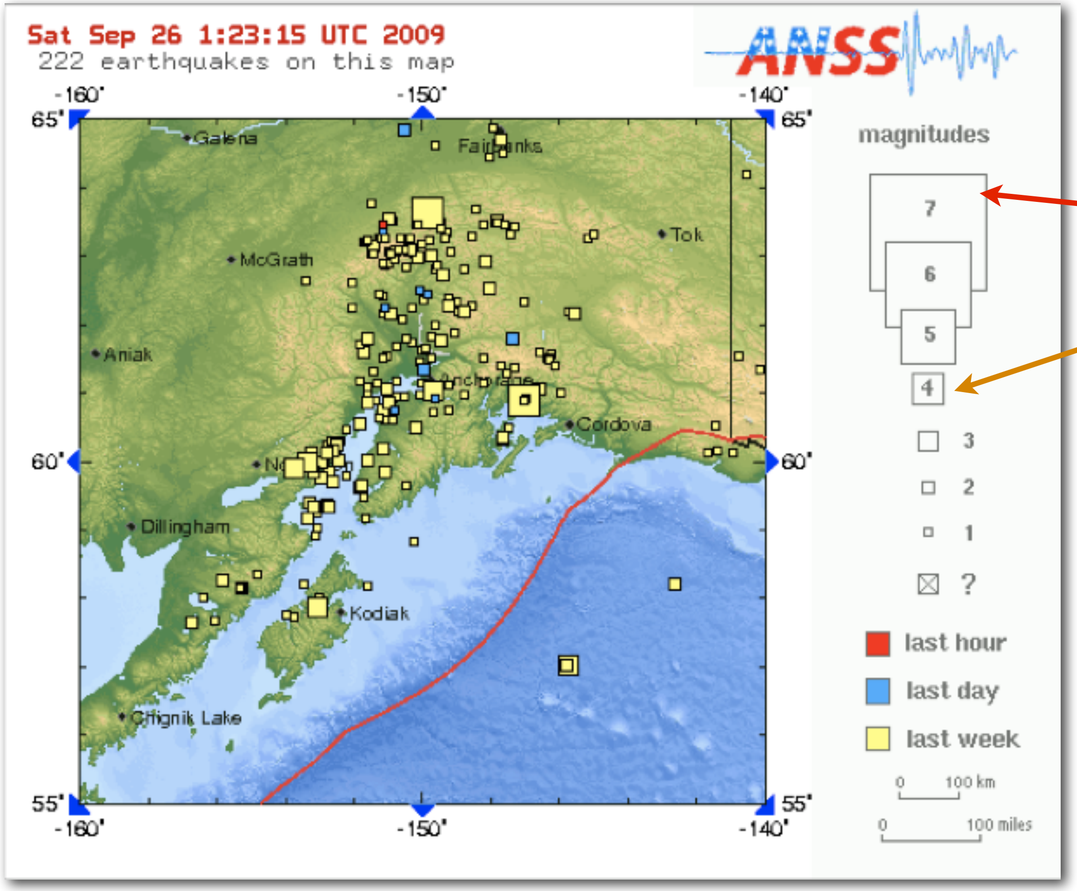
Recurrence Interval

T_R: avg. time between earthquakes of a particular size

$$T_R = N/n$$

N is number of years in the record

n is number of events



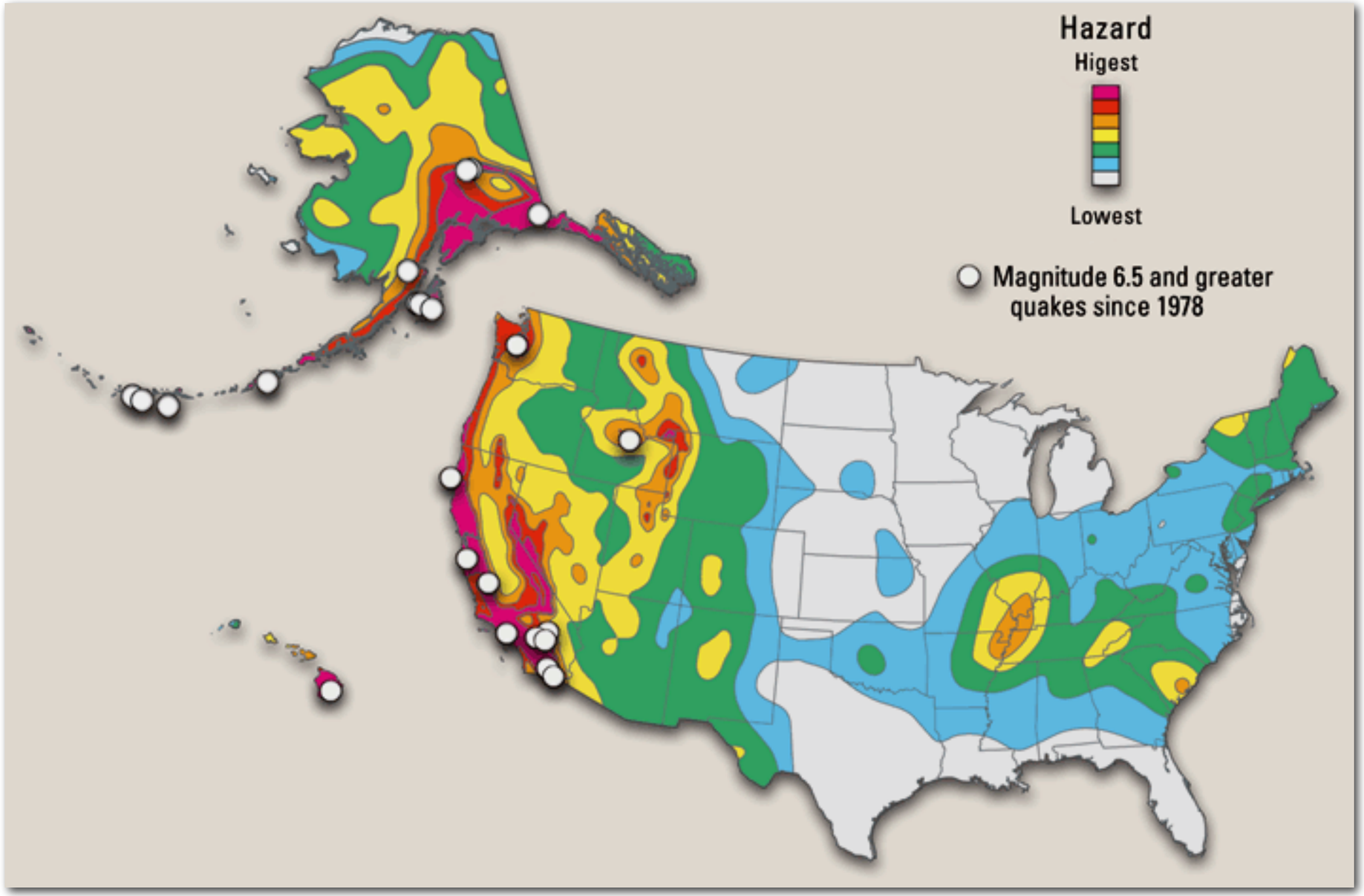
we are more interested in the recurrence interval of large magnitude earthquakes than smaller ones

Earthquakes during the week of Sept 20-27, 2009 - Alaska

http://earthquake.usgs.gov/eqcenter/recenteqsus/Maps/AK10/55.65.-160.-140.php

Hazard Maps

Hazard maps are based on known recurrence intervals

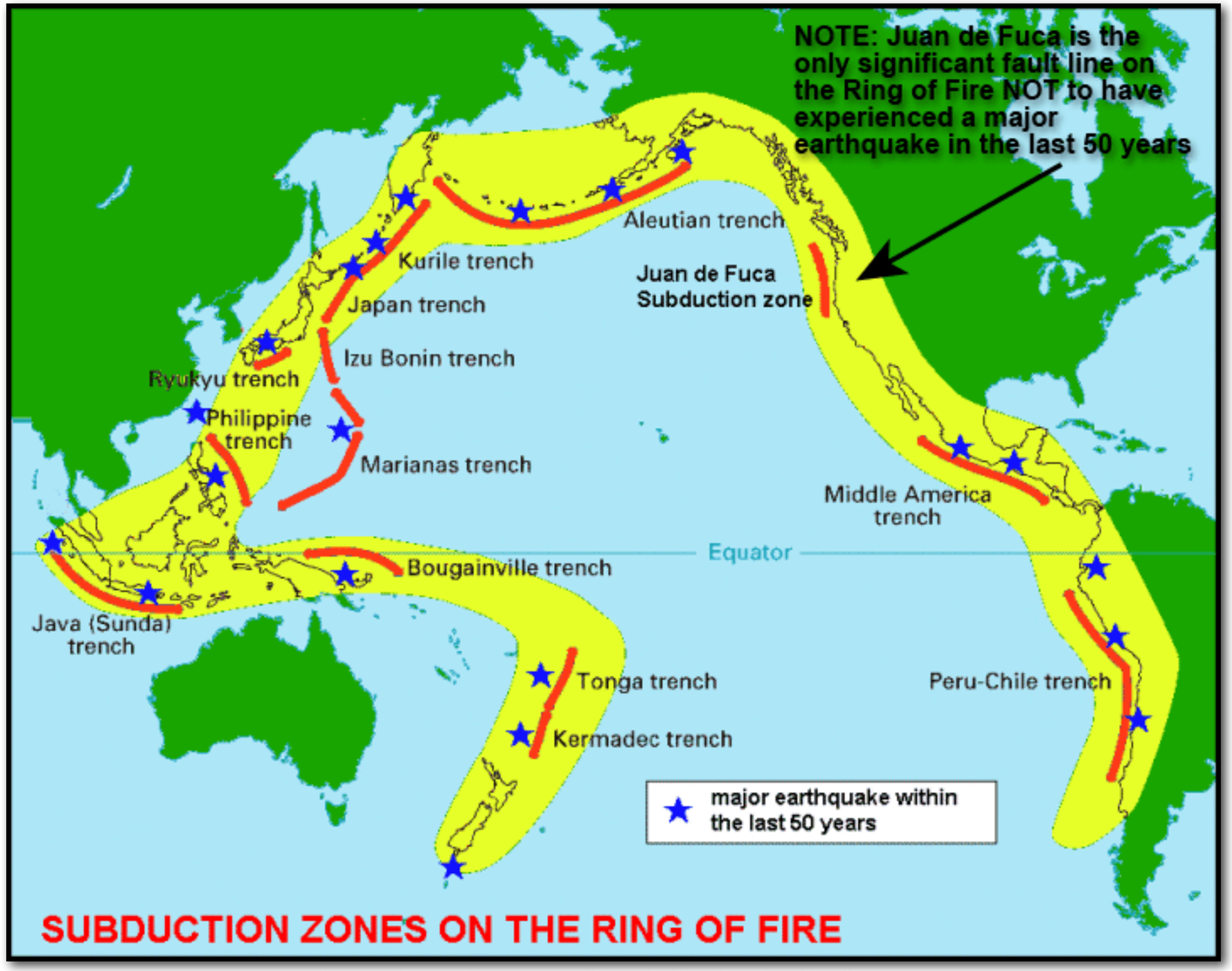


http://web.ics.purdue.edu/~braile/edumod/eqhazard/eqhazard2_files/image003.gif

Convergent boundaries:

(a) subduction zones

"Pacific Ring of Fire" active earthquakes and volcanoes

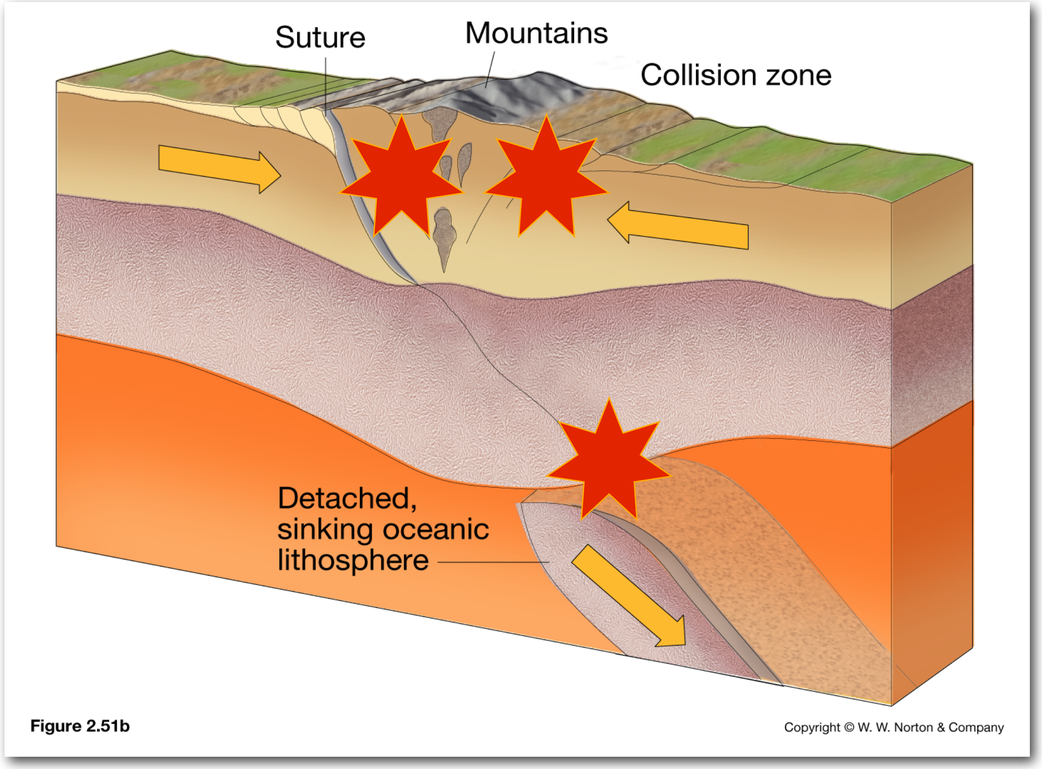


http://www.standeyo.com/Reports/041222.EQ.warning/West.Coast/ring.of.fire.gif

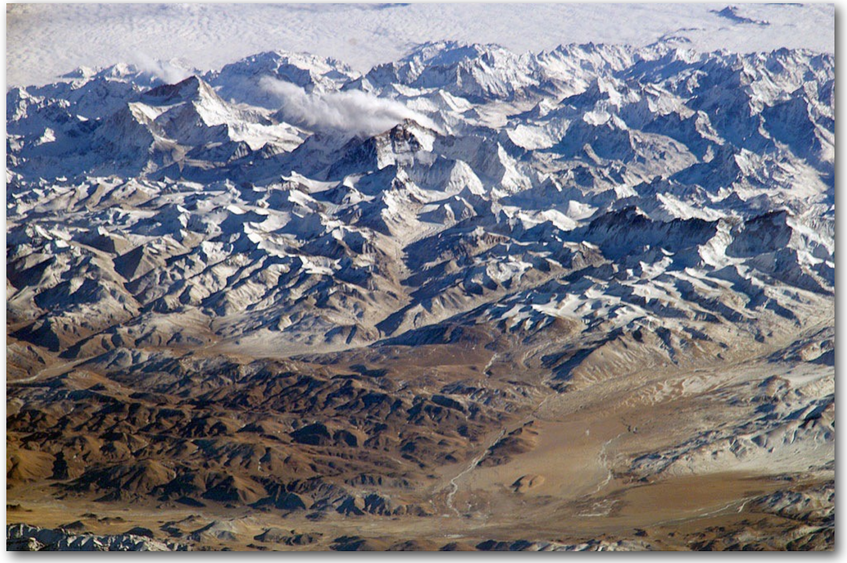
Convergent boundaries:

(b) collision zones

e.g., Himalayas, Zagros Mts. (Iran), Alps, China



very large earthquakes - hardly any volcanoes



http://upload.wikimedia.org/wikipedia/commons/7/79/Himalayas.jpg

Sichuan province, China 2008

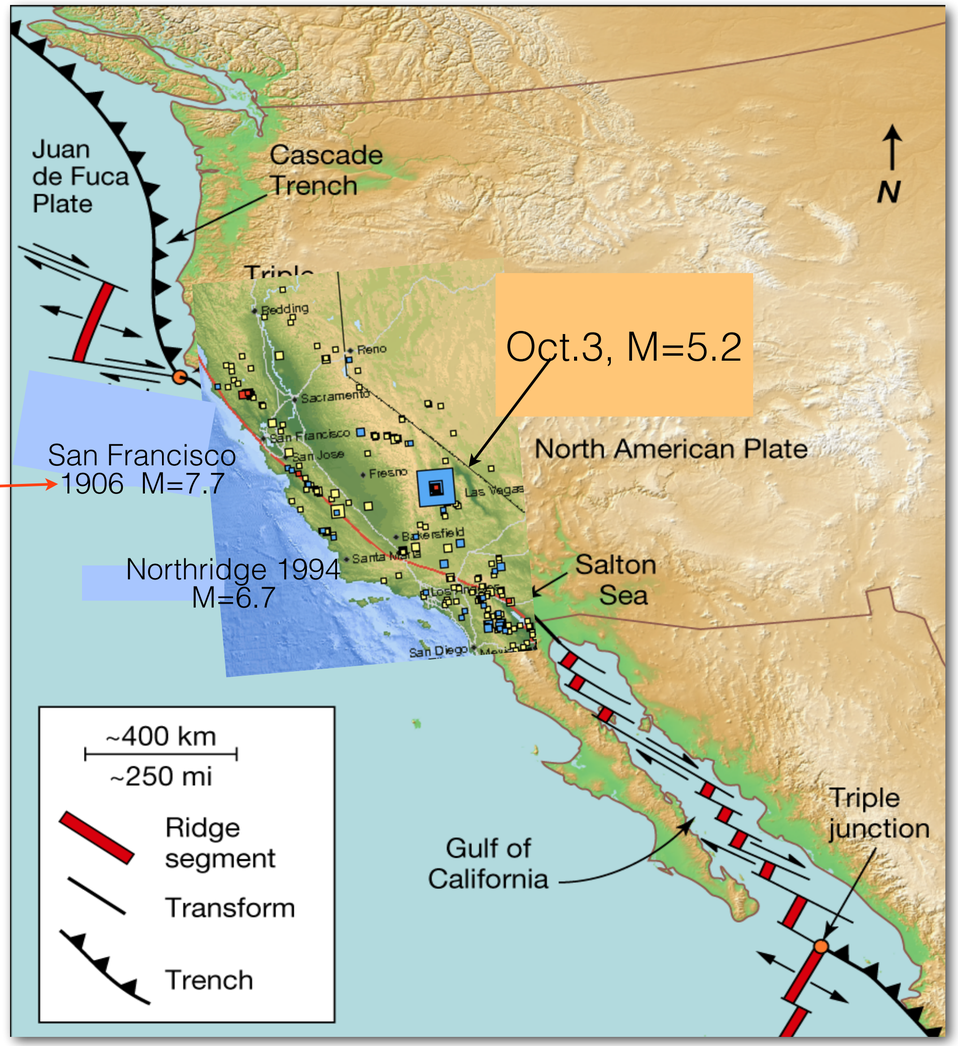
http://i.telegraph.co.uk/telegraph/multimedia/archive/01112/earthquake-damage-_1112578c.jpg

Transform boundaries:

e.g., California, New Zealand

Very Sticky!
Lots of Earthquakes

Mostly shallow depth, but can be large magnitude and have destructive ground shaking



http://earthquake.usgs.gov/regional/states/events/images/1906_04_18_016_small.gif

Hazard Maps

http://www.shakeout.org