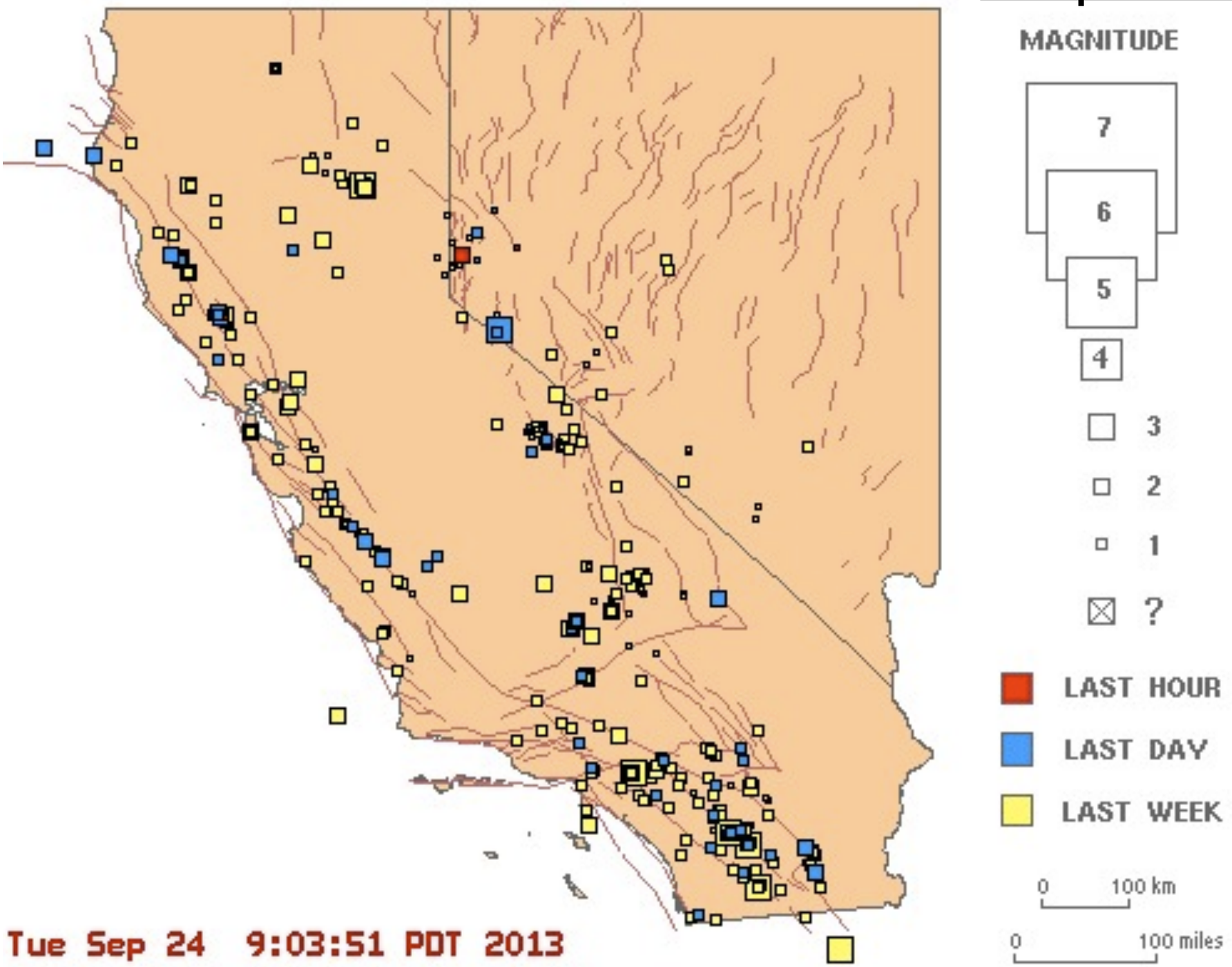
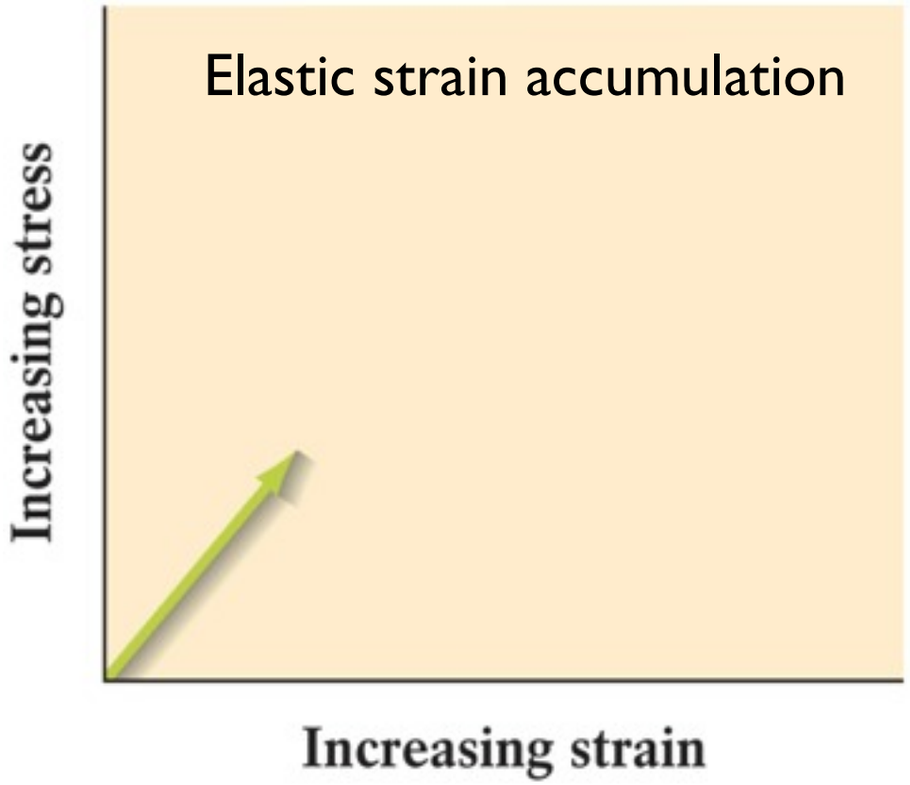
Earthquakes and Earth's Structure

Chapter 10 and 11 (review)



http://earthquake.usgs.gov/earthquakes/recenteqsus/

Elastic and Brittle Strain



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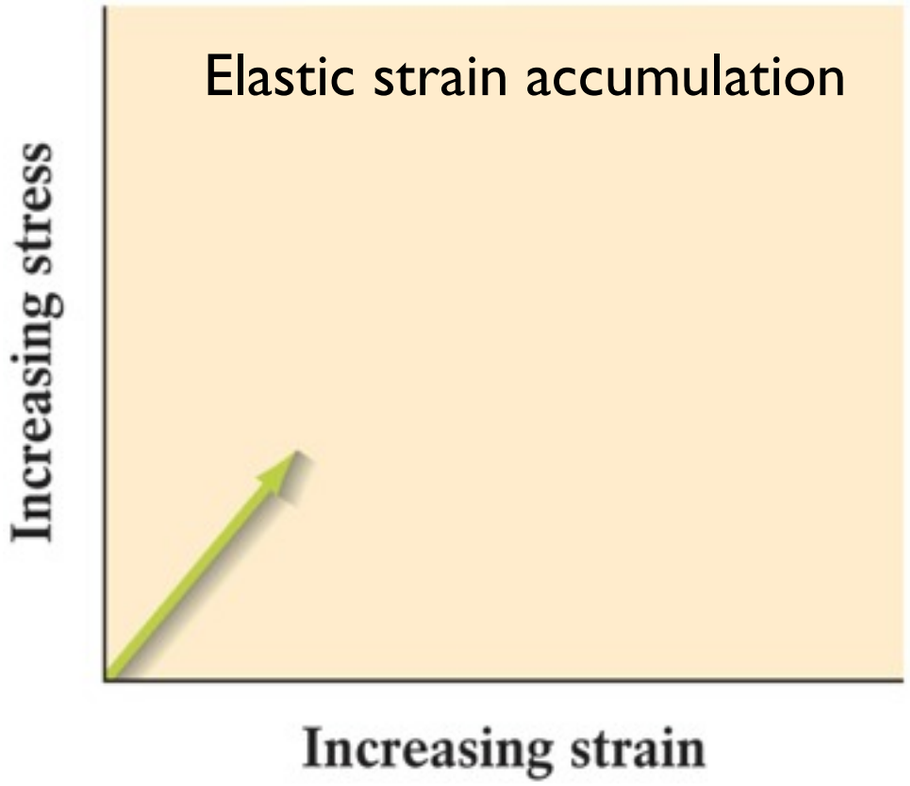
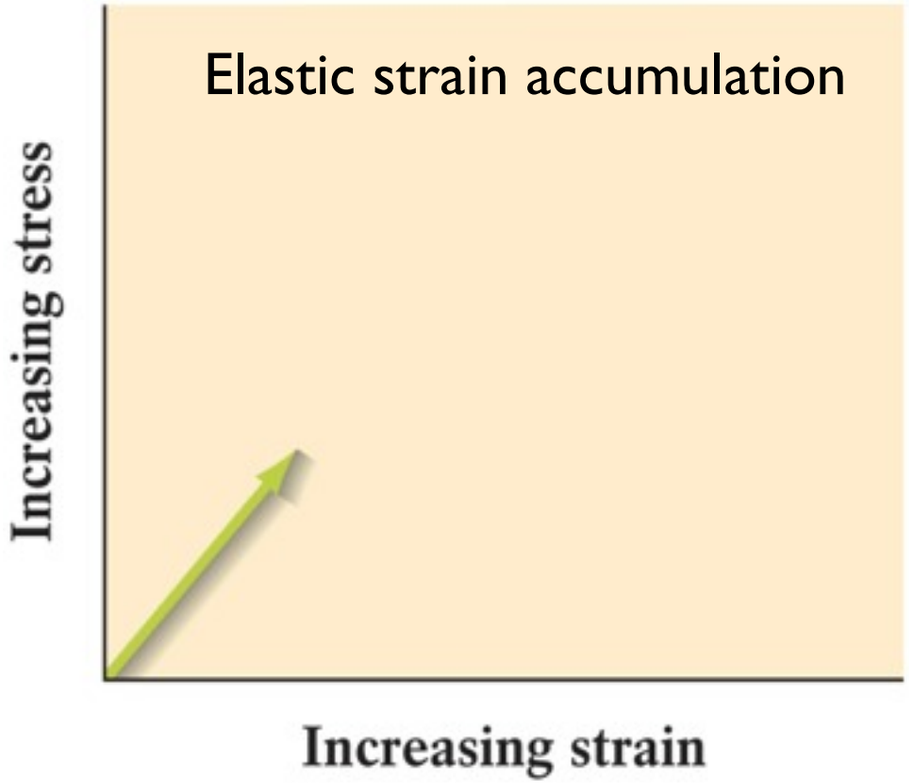
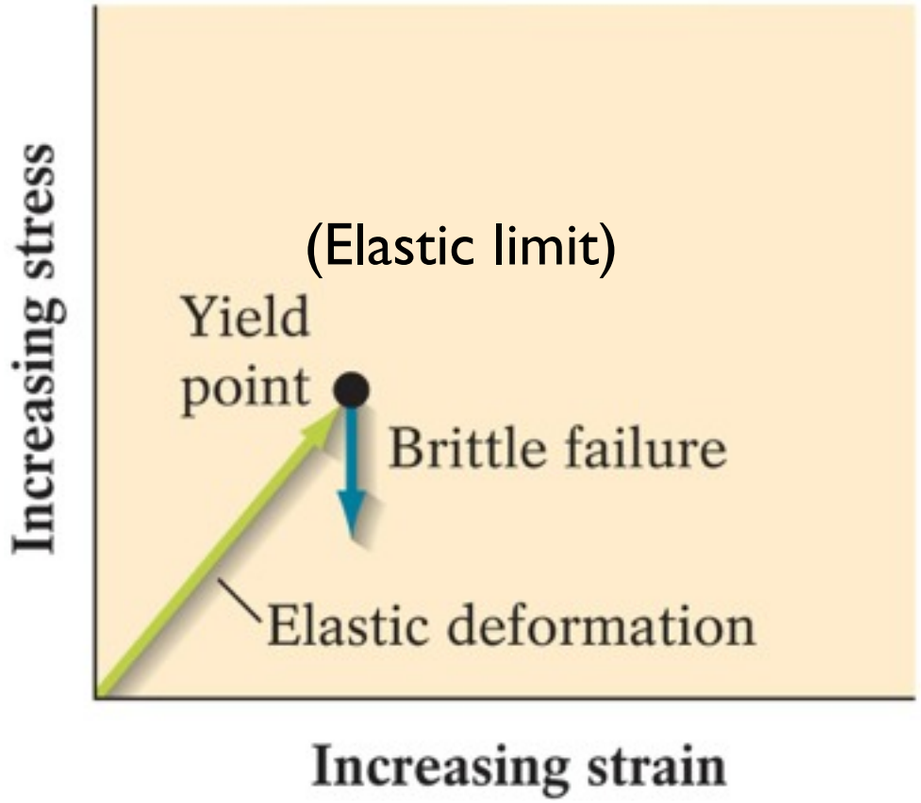


Elastic Strain - Recoverable strain. Strain energy is stored in the rocks.

Elastic and Brittle Strain

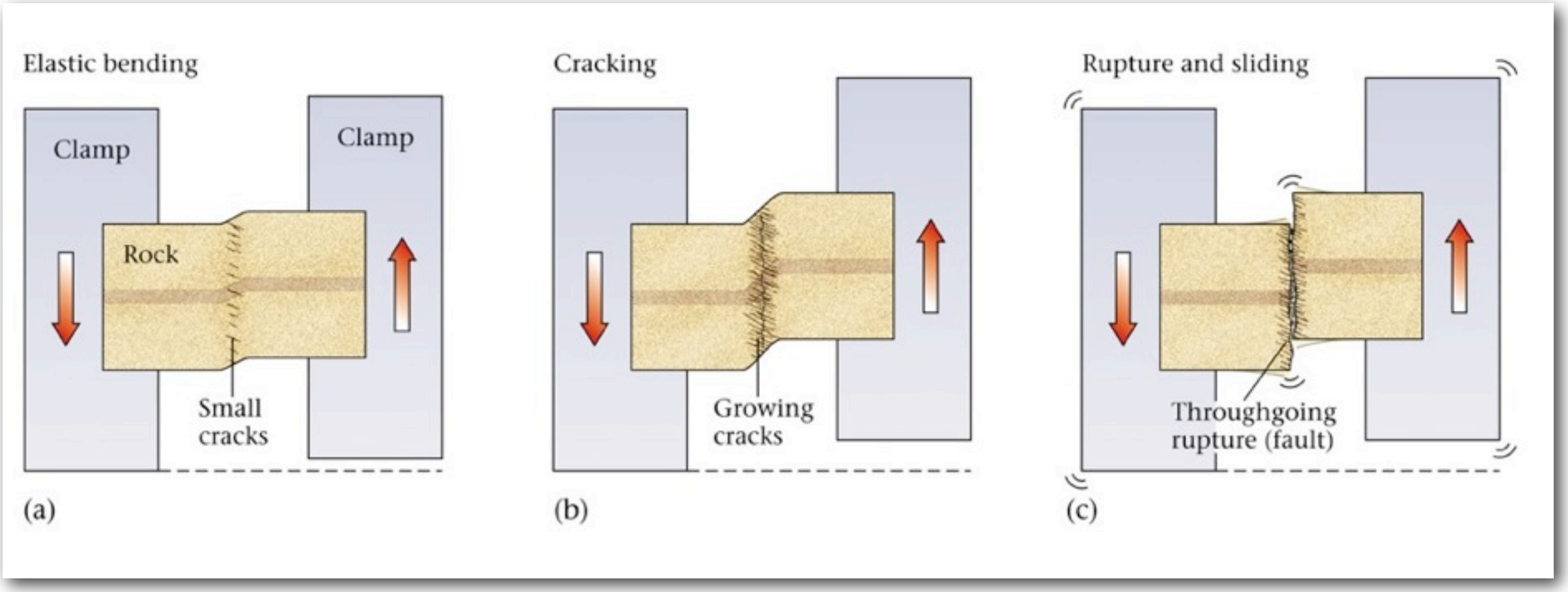




Elastic Strain - Recoverable strain. Strain energy is stored in the rocks.

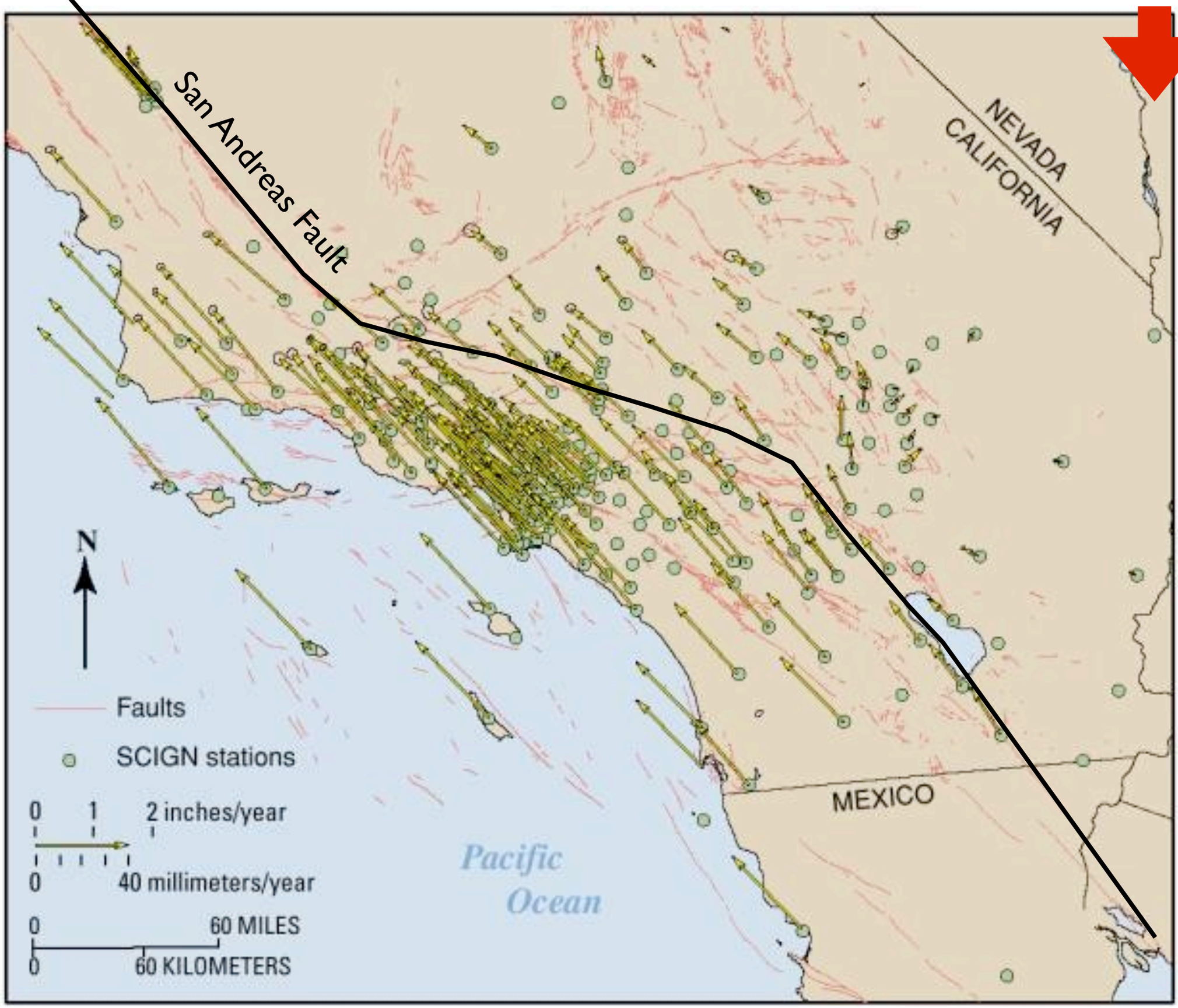
Brittle Failure - Brittle failure occurs when rock or fault strength is surpassed. Stored elastic energy is released in the form of an earthquake

Elastic Rebound Theory



1. Stress (force/area) is continually applied to rocks or pre-existing faults.
   -This stress most likely comes from plate tectonics and is localized near plate boundaries.
2. Stress builds where strong rocks or locked faults withstand it.
   -(Friction is the internal force that locks a fault, making its two sides stick together.)
3. Rocks deform elastically (strain) in response to the building stress.
4. Stress ultimately builds to a critical point (Yield point) and rock strength or fault friction gives and rock breaks or fault slips.
5. Energy stored in the form of elastically deformed rocks is released as seismic waves that move outward in all directions.
6. After the rocks or faults have settled back into place, the stress begins building again.

Elastic Strain in Southern California



Brittle Strain in California

Brittle Strain in California

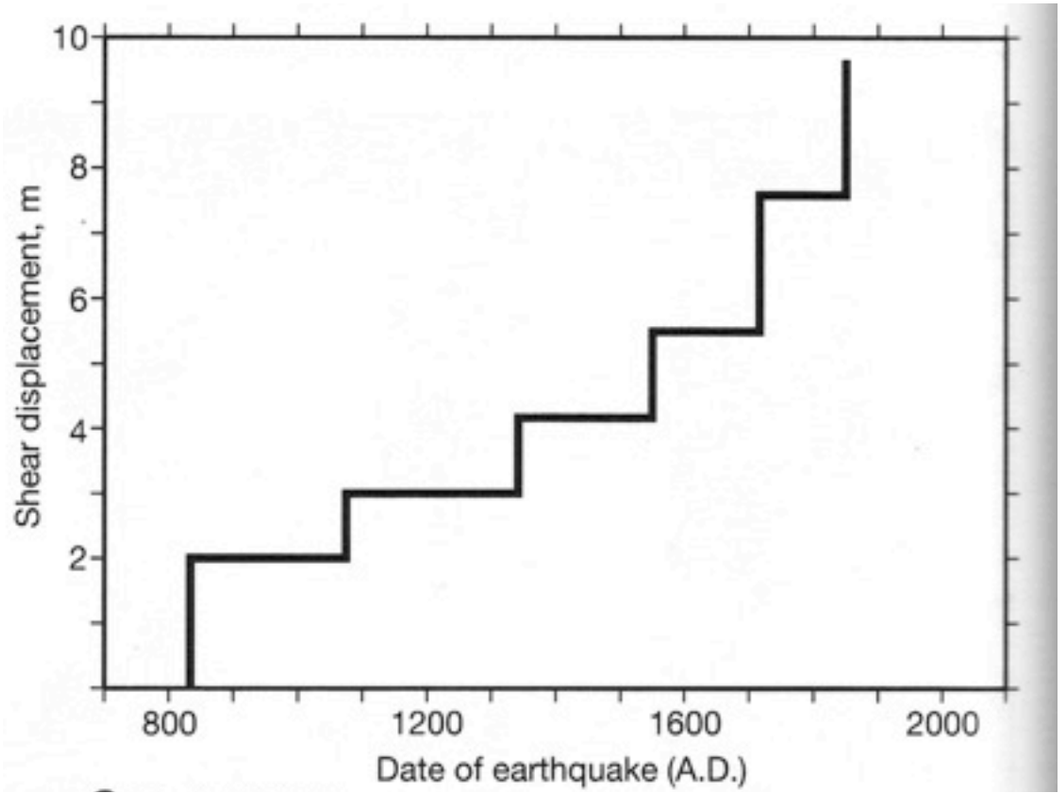
Brittle Strain in California

California Coast Ranges
500-2500 ft

San Gabriel Mountains
>10,000 ft

Earthquake Rupture Patterns
Brittle failure and the concept of "Stick- Slip"

San Andreas fault 800-2000 AD



Stick = Yearly elastic strain accumulation

Slip = Earthquake and strain energy release

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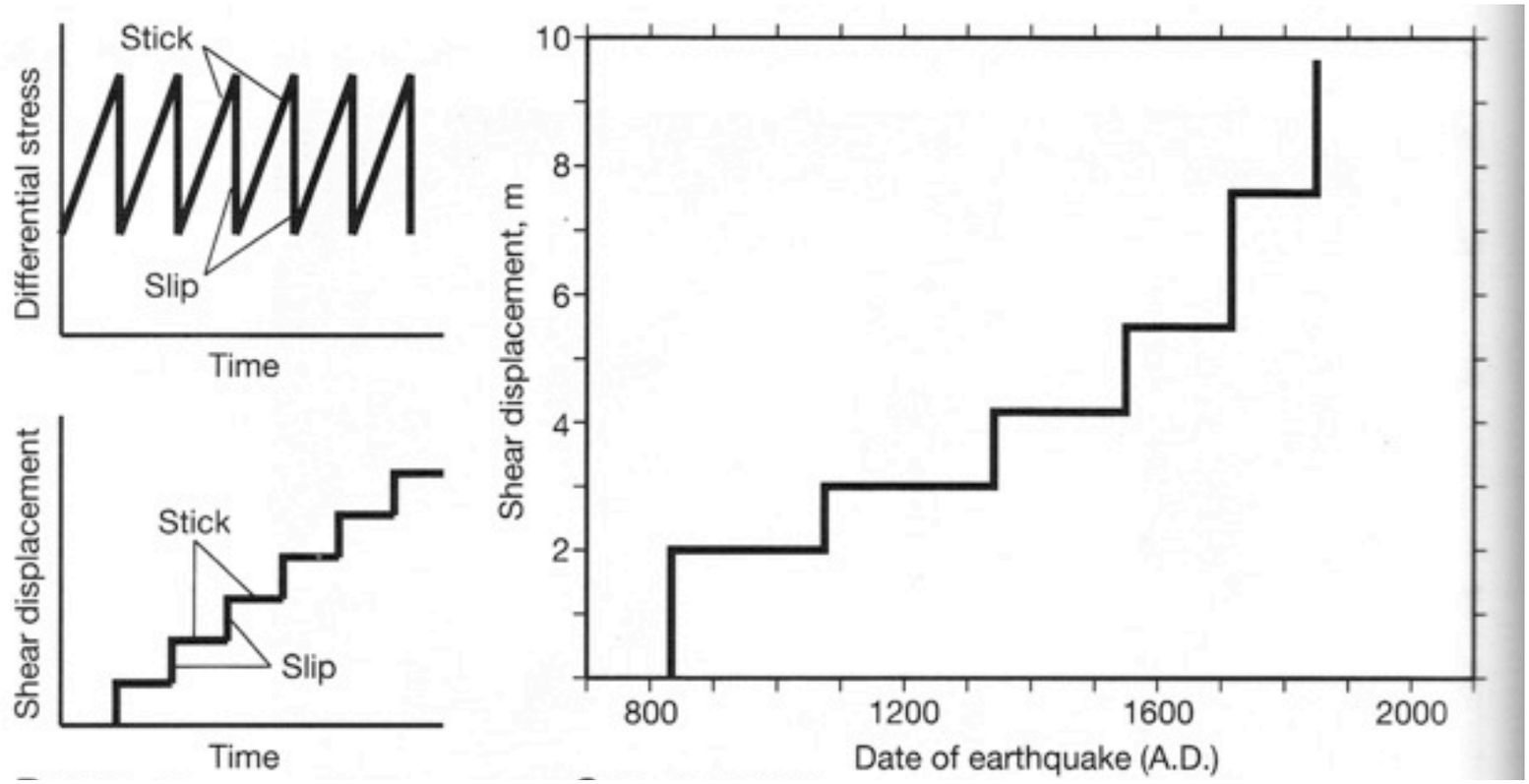

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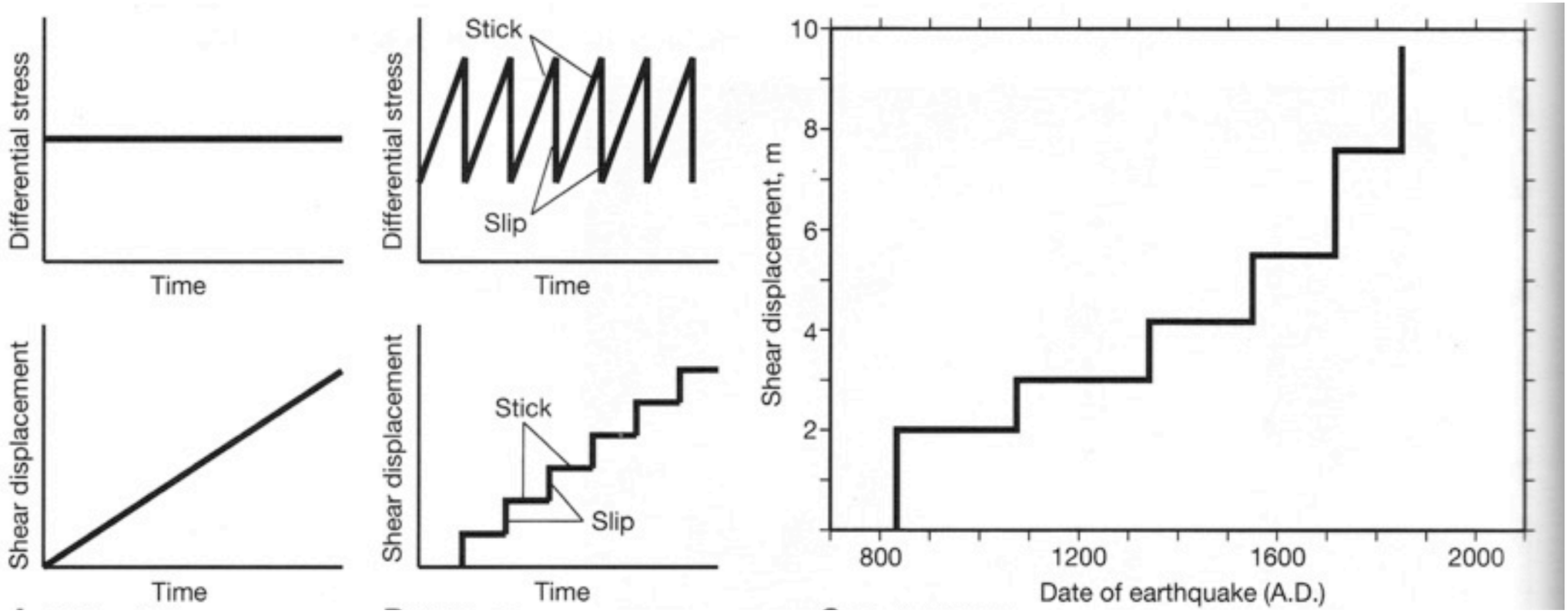

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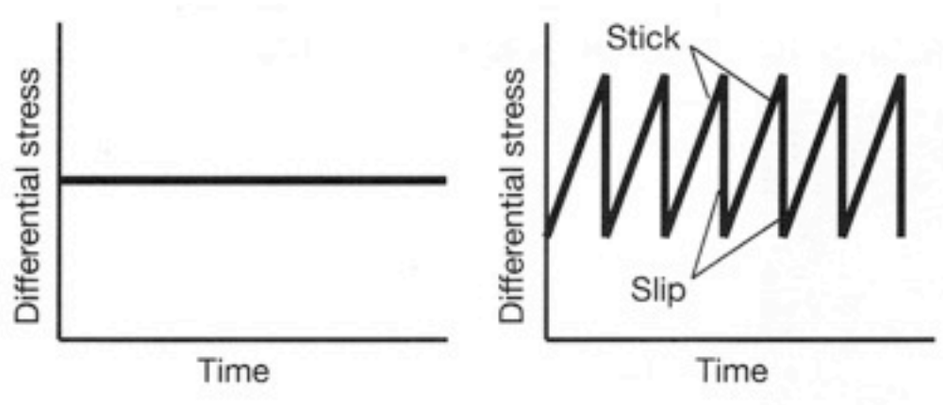

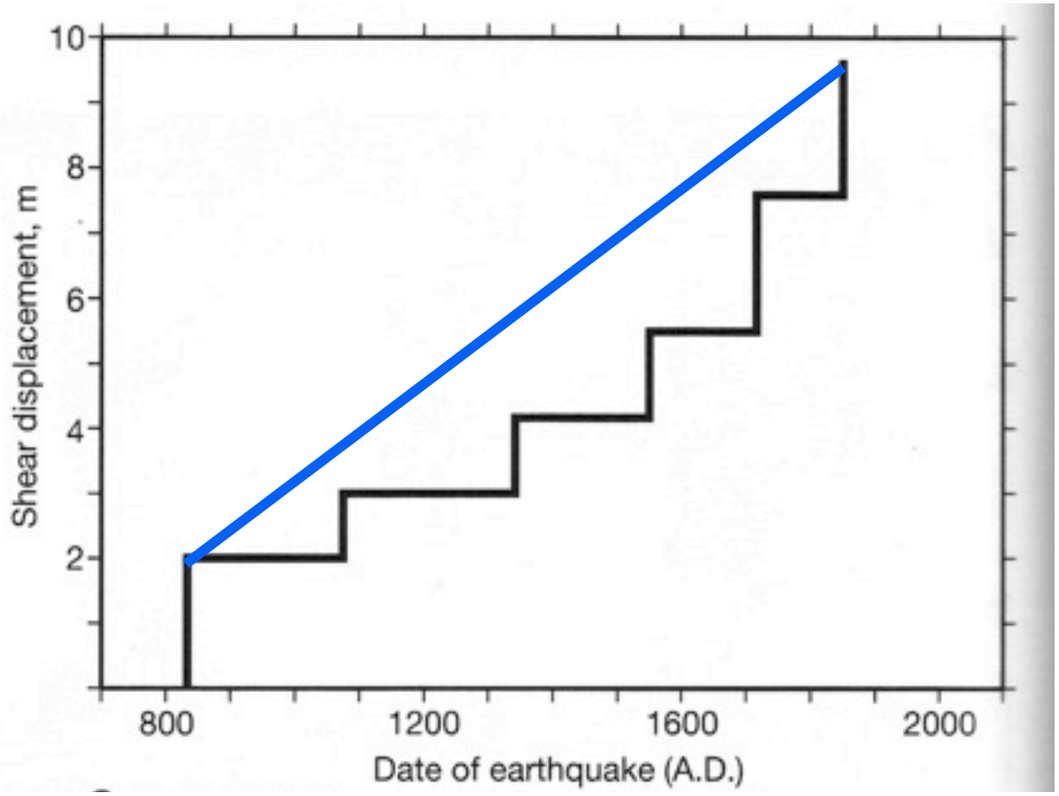

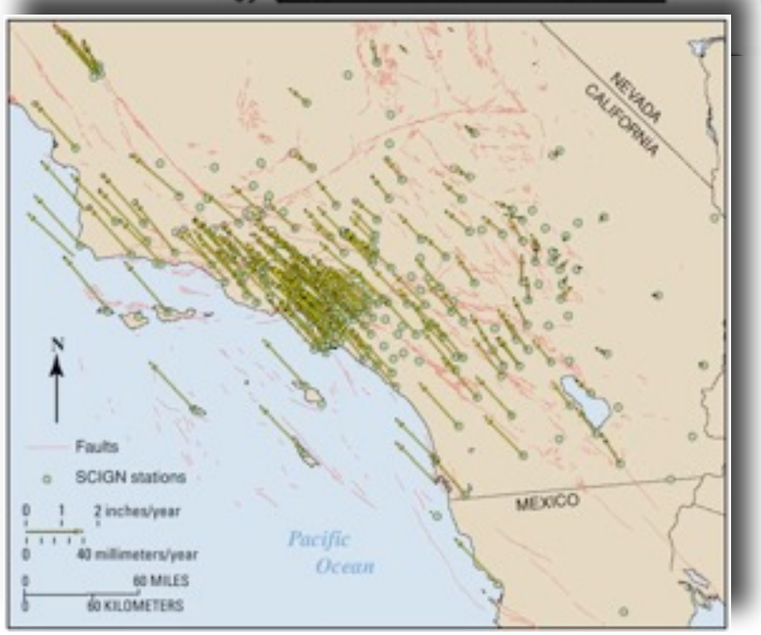

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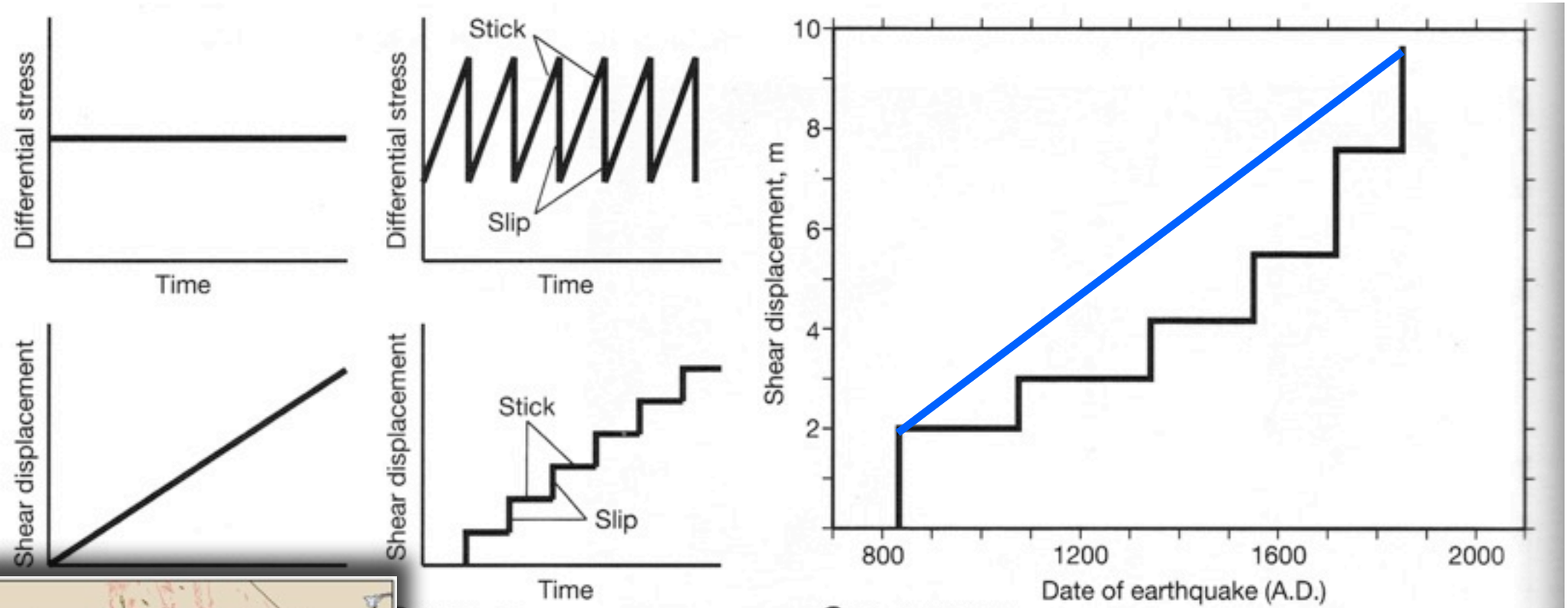
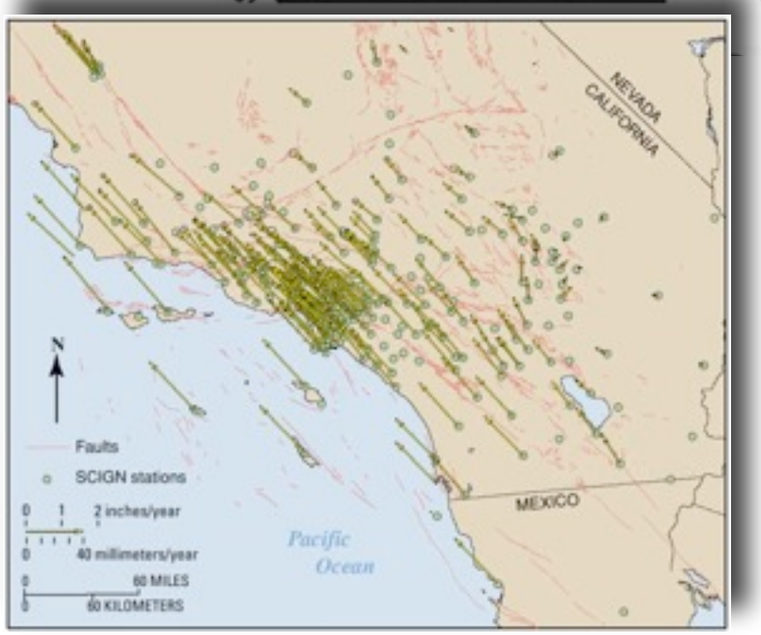


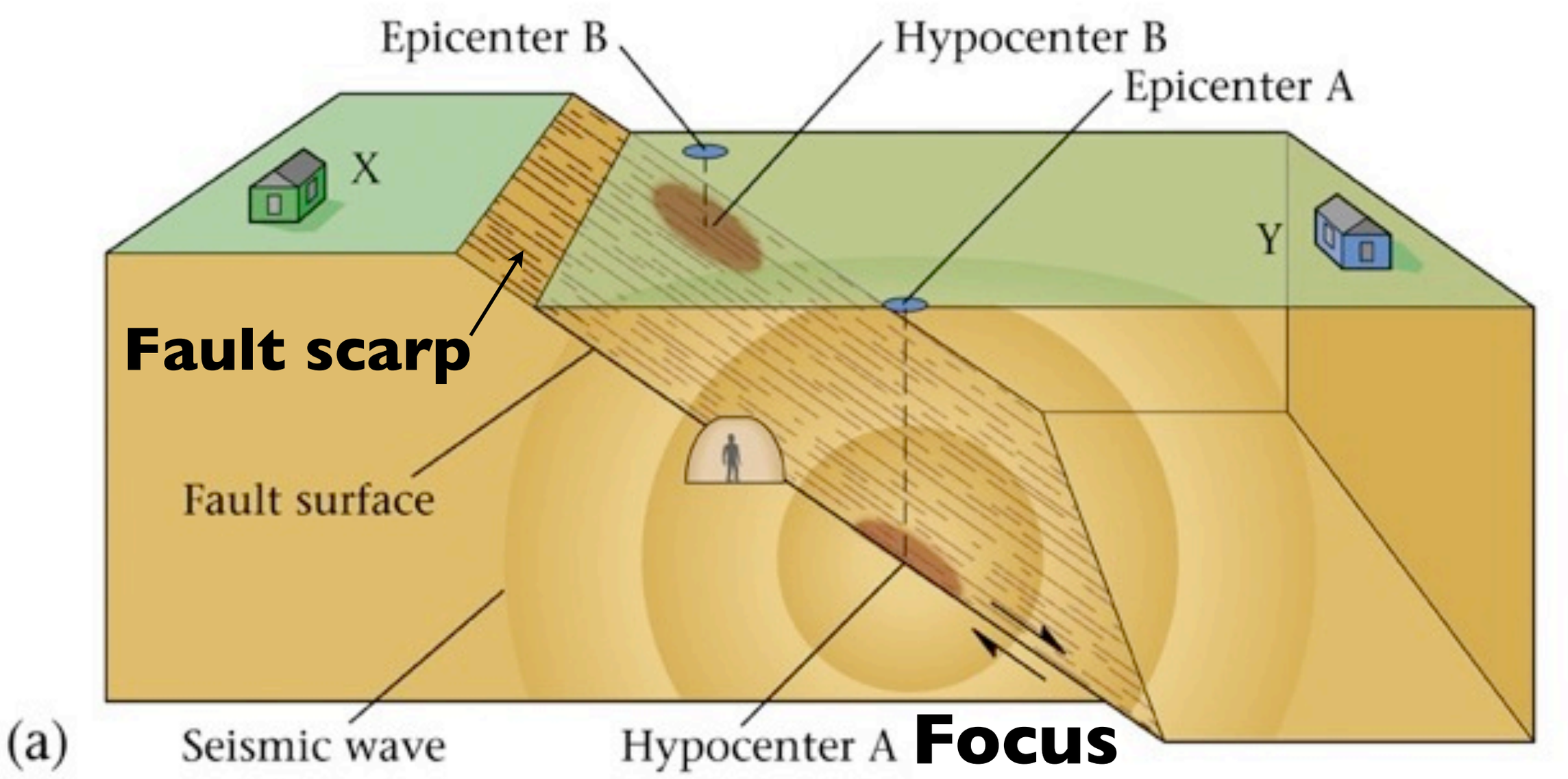


7.5m / 1,106yr = 6.8 cm/yr

Stick = Yearly elastic Strain Accumulation

Slip = Earthquake and strain energy release

Elastic Energy Release and Non-recoverable brittle strain



Focus

Epi- on or over

Hypo - Under or beneath

Shown below is the fault scarp that formed during the 1999 Chi Chi Earthquake in Taiwan. The best way to determine whether this fault occurred as a result of shortening or extension, would be to determine

A) The age of the rocks that have been deformed by the fault.
B) The magnitude of the earthquake.
C) The amount of slip that occurred.
D) The dip direction of the fault plane.
E) None of the above

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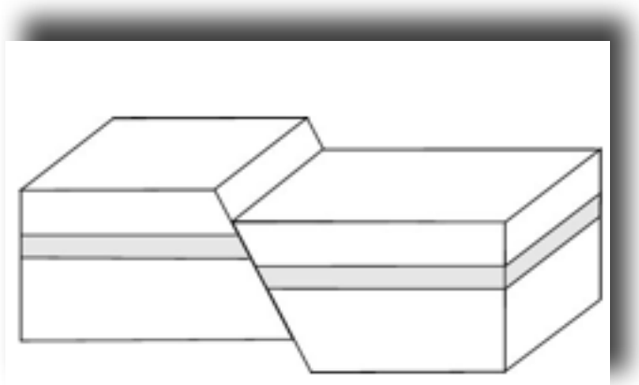

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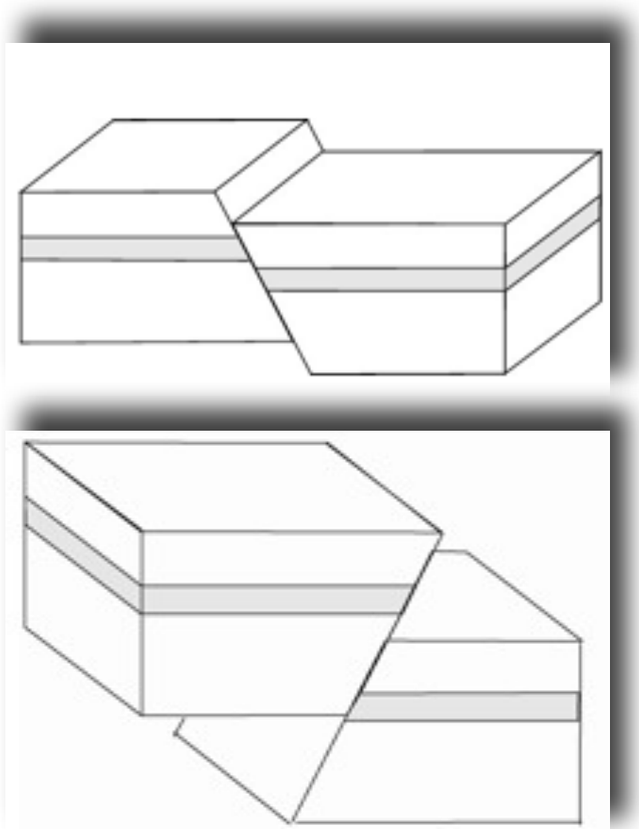

The map below shows the location of Taiwan positioned along the "Ring of Fire" in the western Pacific ocean (red circle). What type of stress do you think was the cause of the Earthquake?

A) Compressional
B) Tensional
C) Shearing
D) Folding
E) Faulting

The map below shows the location of Taiwan positioned along the "Ring of Fire" in the western Pacific ocean (red circle). What type of stress do you think was the cause of the Earthquake?

A) Compressional
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D) Folding
E) Faulting

Now that you know that the Chi Chi Earthquake was caused by compression, which way is the fault dipping?

A) West
B) East
C) North
D) South
E) Don't know

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A) West
B) East
C) North
D) South
E) Don't know

What is the approximate magnitude of dip-slip displacement on the fault?

A) 6 ft (2m)
B) 9 ft (3m)
C) 21 ft (7m)
D) it can't be determined from this photo.

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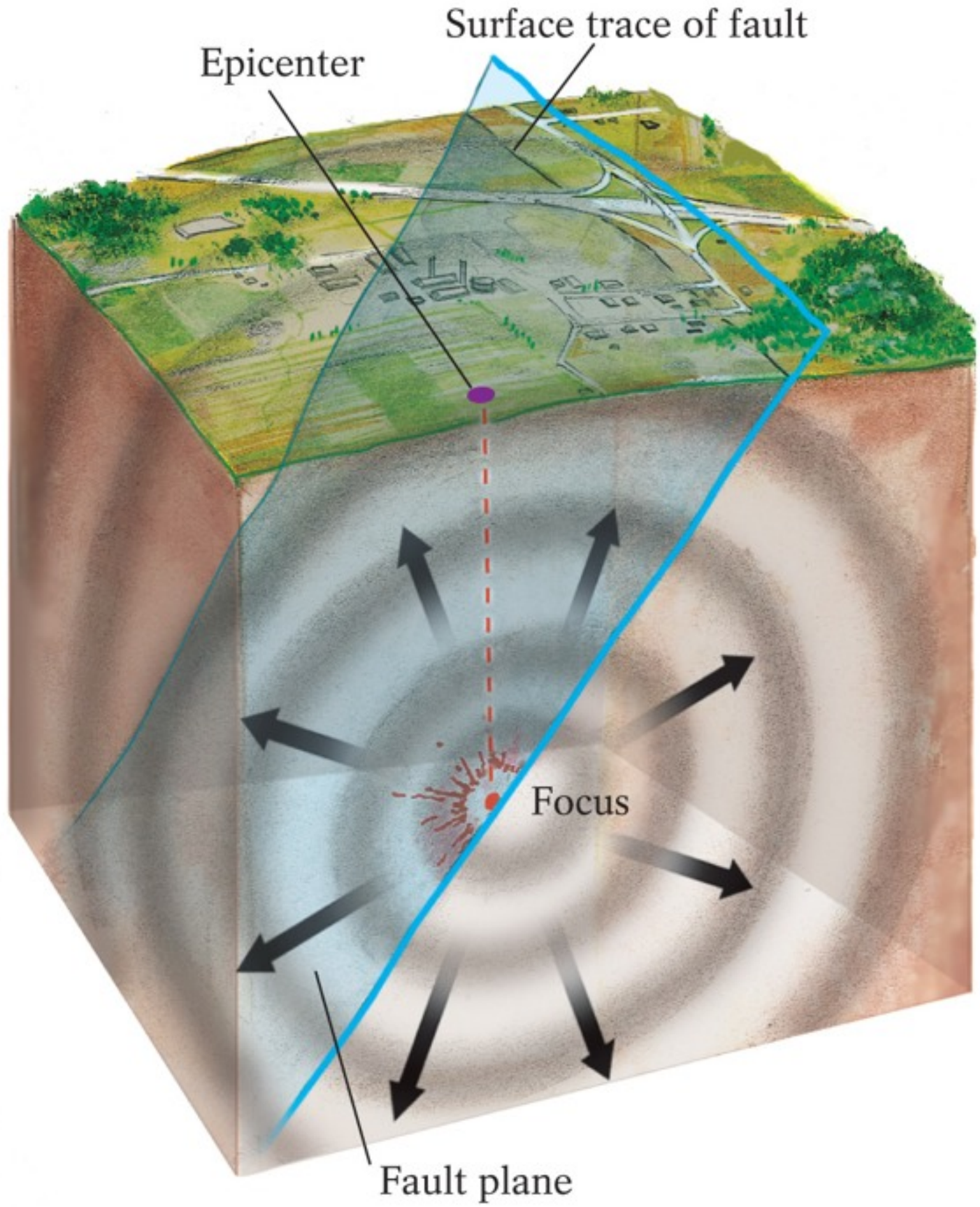
Seismic Waves are generated by the release of elastic strain stored in the rocks



Seismic waves associated with Earthquakes

Name	Type	Propagation	Travels through
P-wave	Compressional ***Body*** wave		
S-wave	Shear ***Body*** wave		

Love wave	Shear ***Surface*** wave		
Rayleigh wave	Orbital ***Surface*** wave		

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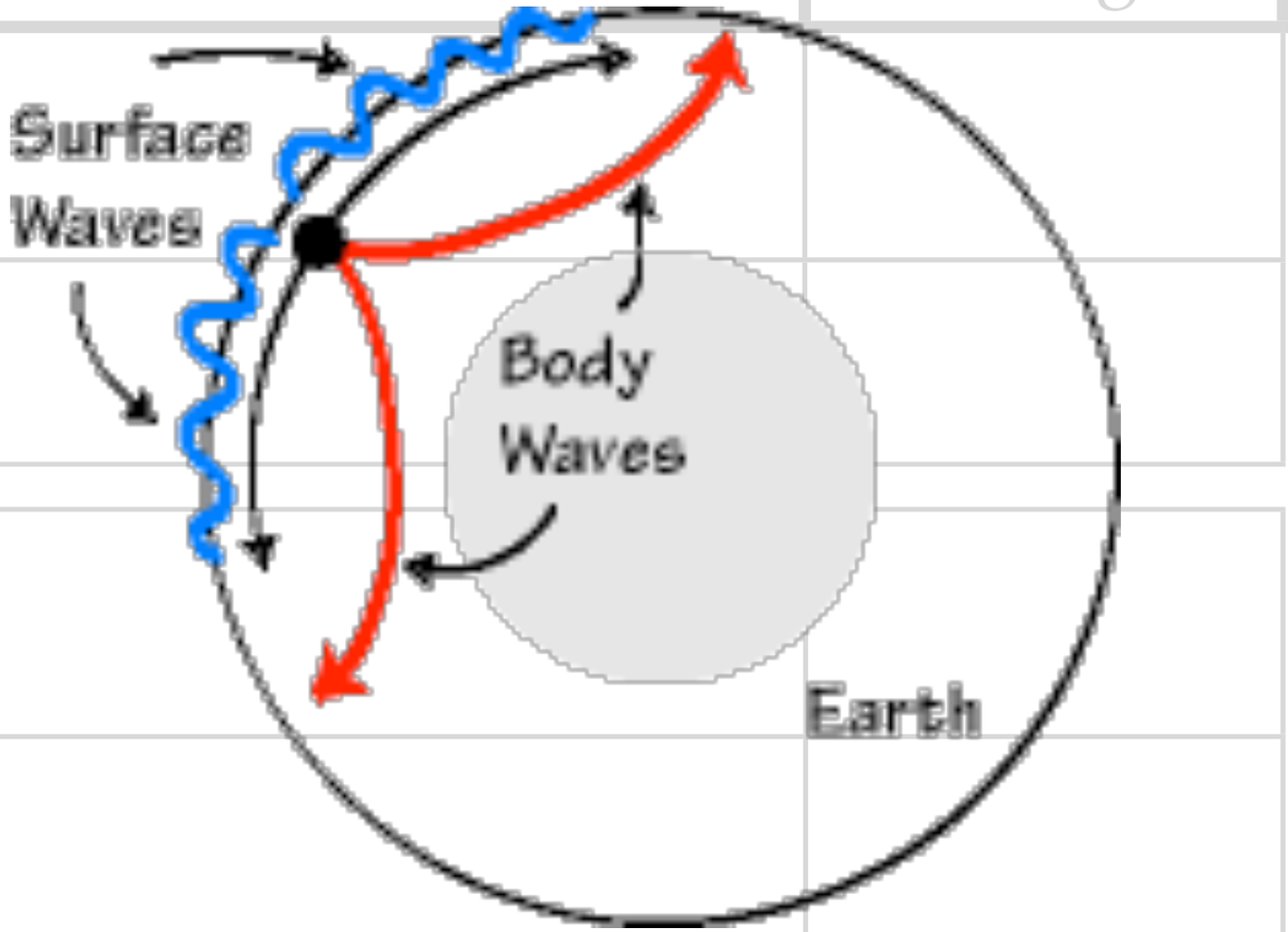
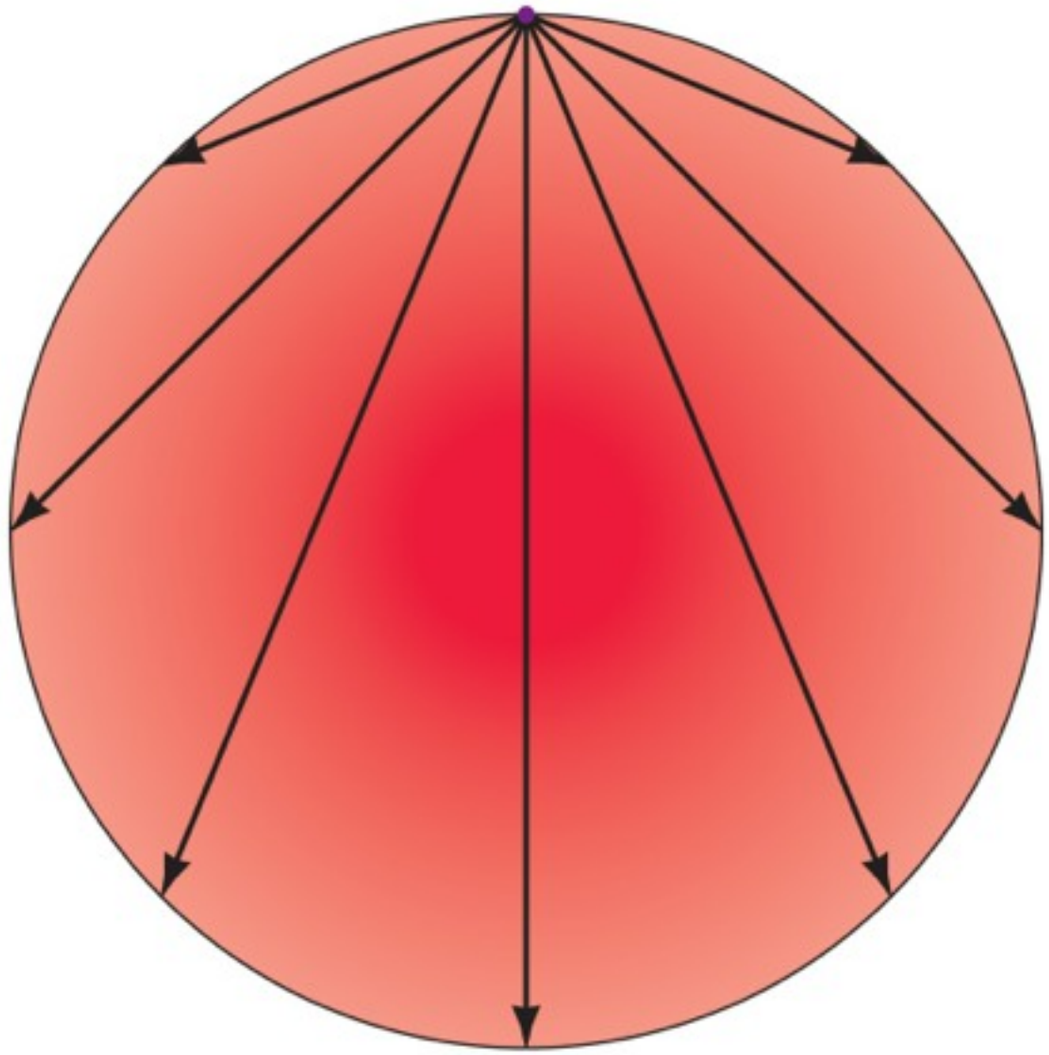
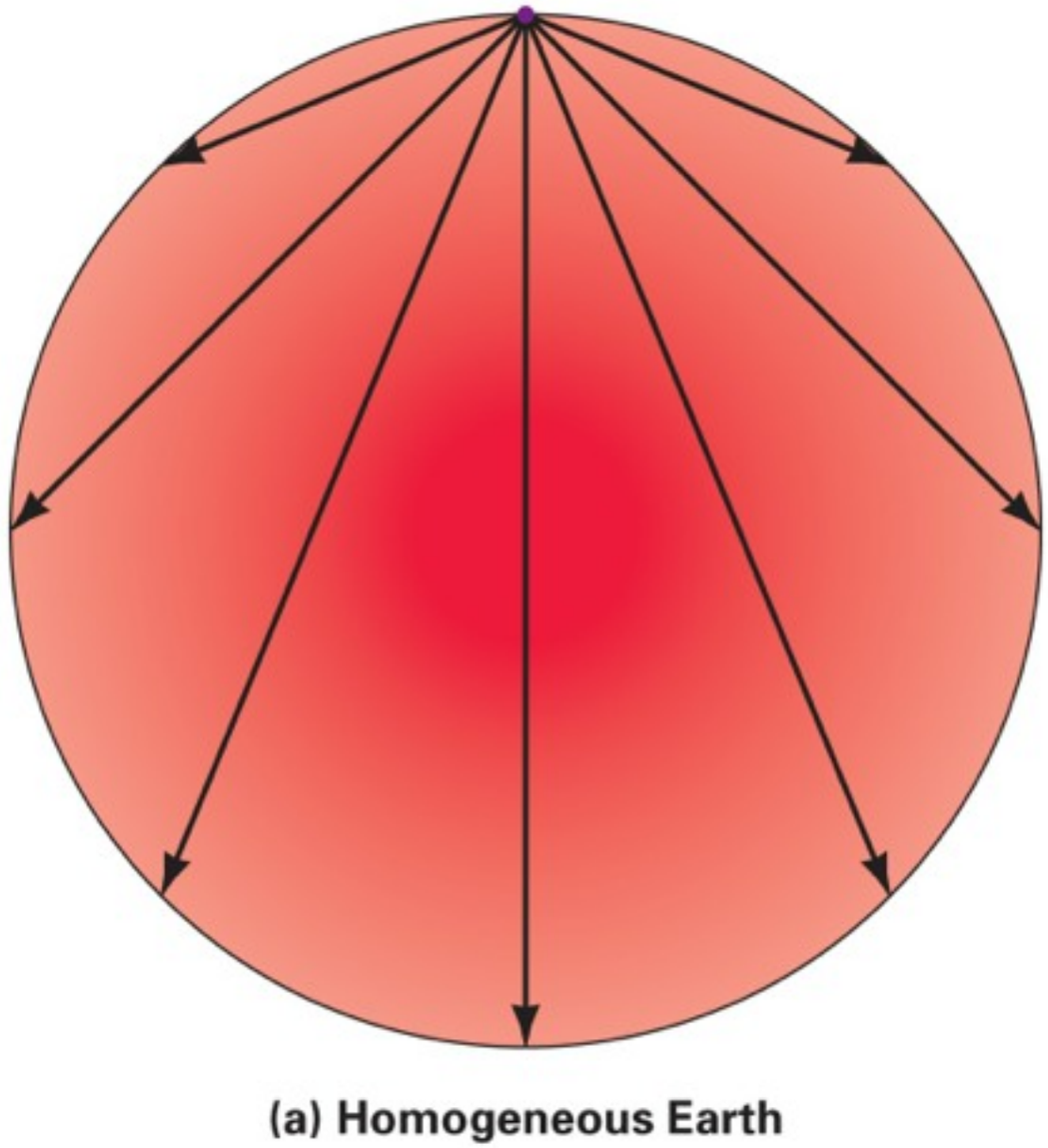


Name	Type
P-wave	Compressional ***Body*** wave
S-wave	Shear ***Body*** wave



(a) Homogeneous Earth

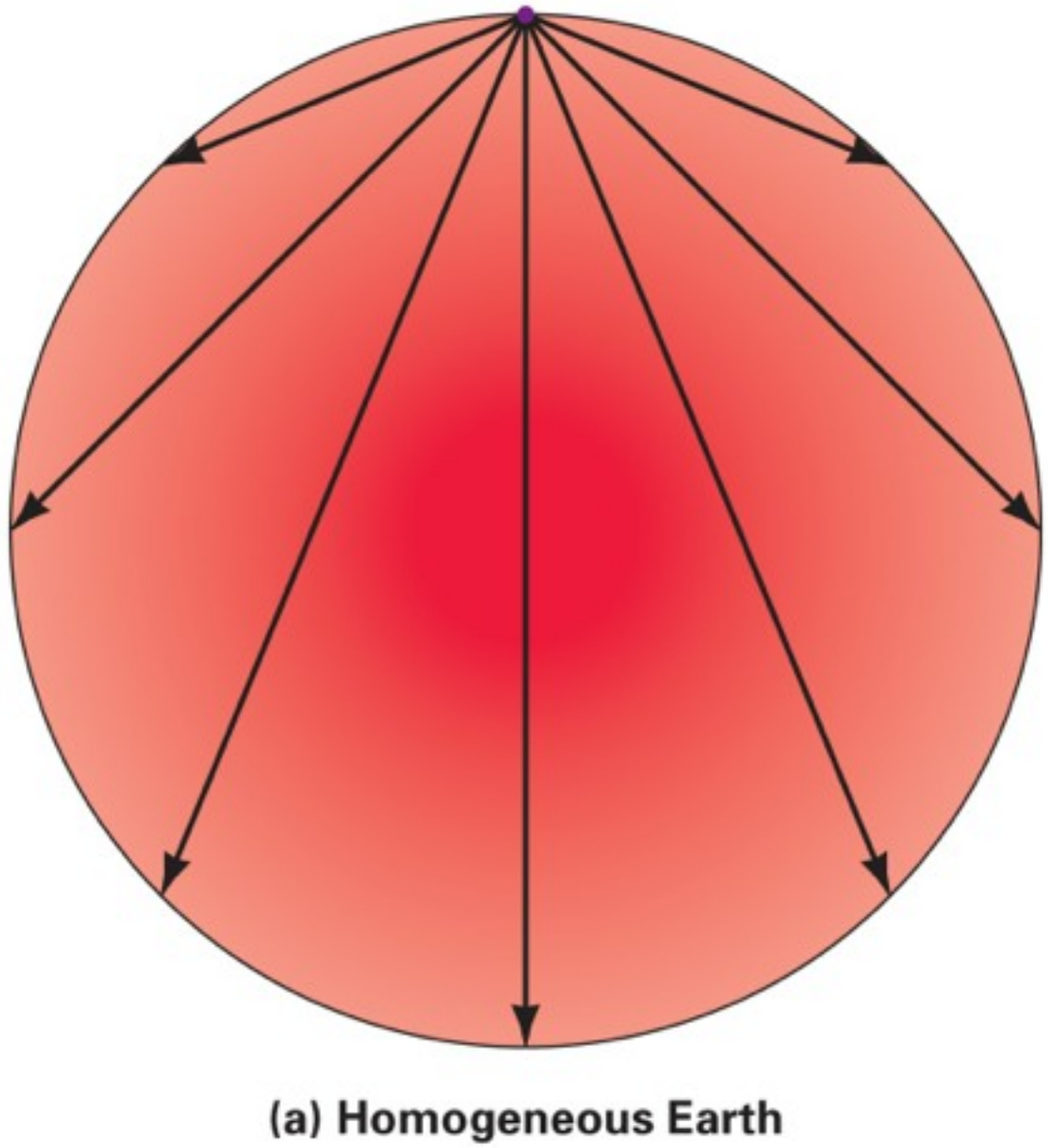
Name	Type
P-wave	Compressional ***Body*** wave
S-wave	Shear ***Body*** wave



(a) Homogeneous Earth

Earth is layered

Name	Type
P-wave	Compressional ***Body*** wave
S-wave	Shear ***Body*** wave

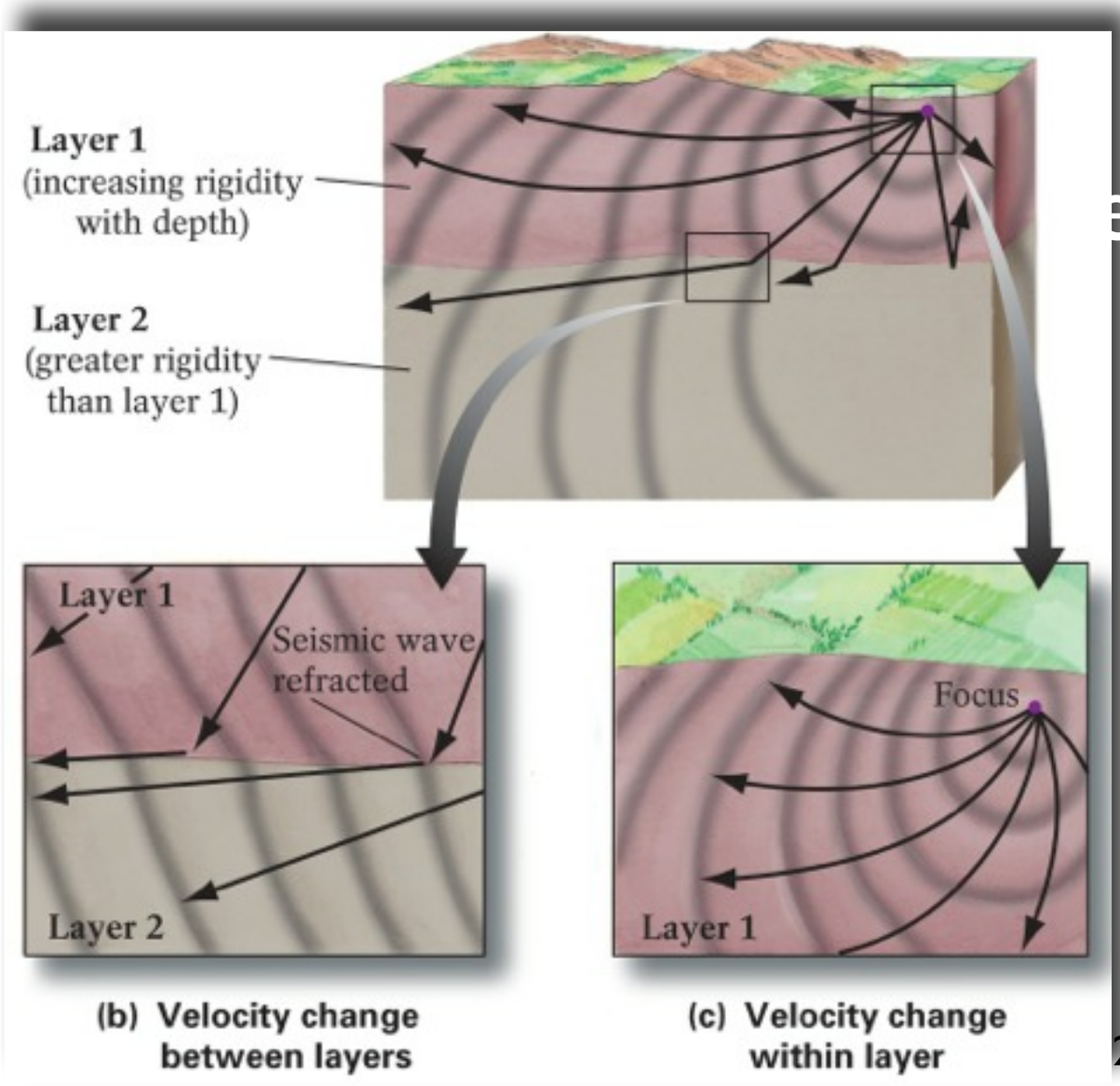


(a) Homogeneous Earth

Earth is layered

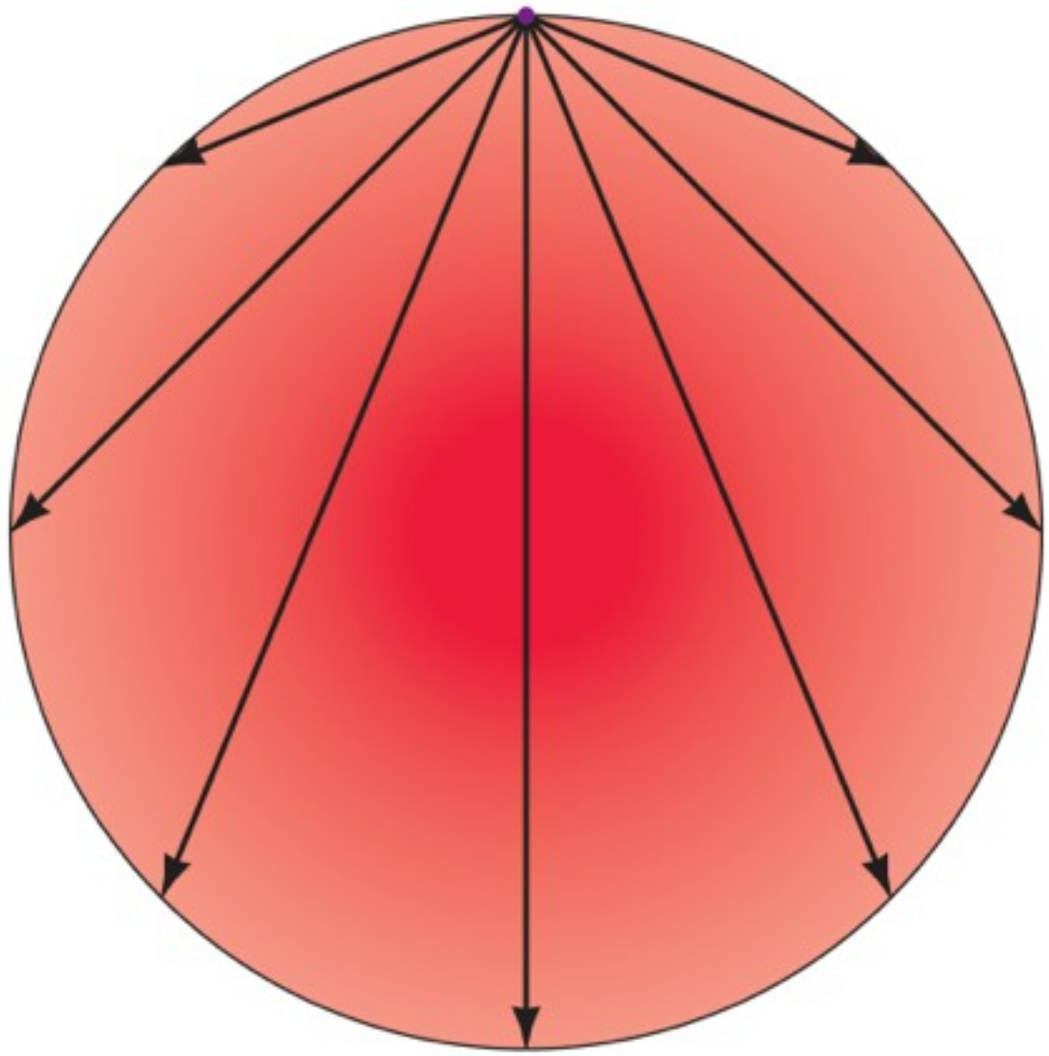
Compositional and Rheologic

Name	Type
P-wave	Compressional ***Body*** wave
S-wave	Shear ***Body*** wave



(b) Velocity change between layers

(c) Velocity change within layer



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Name	Type
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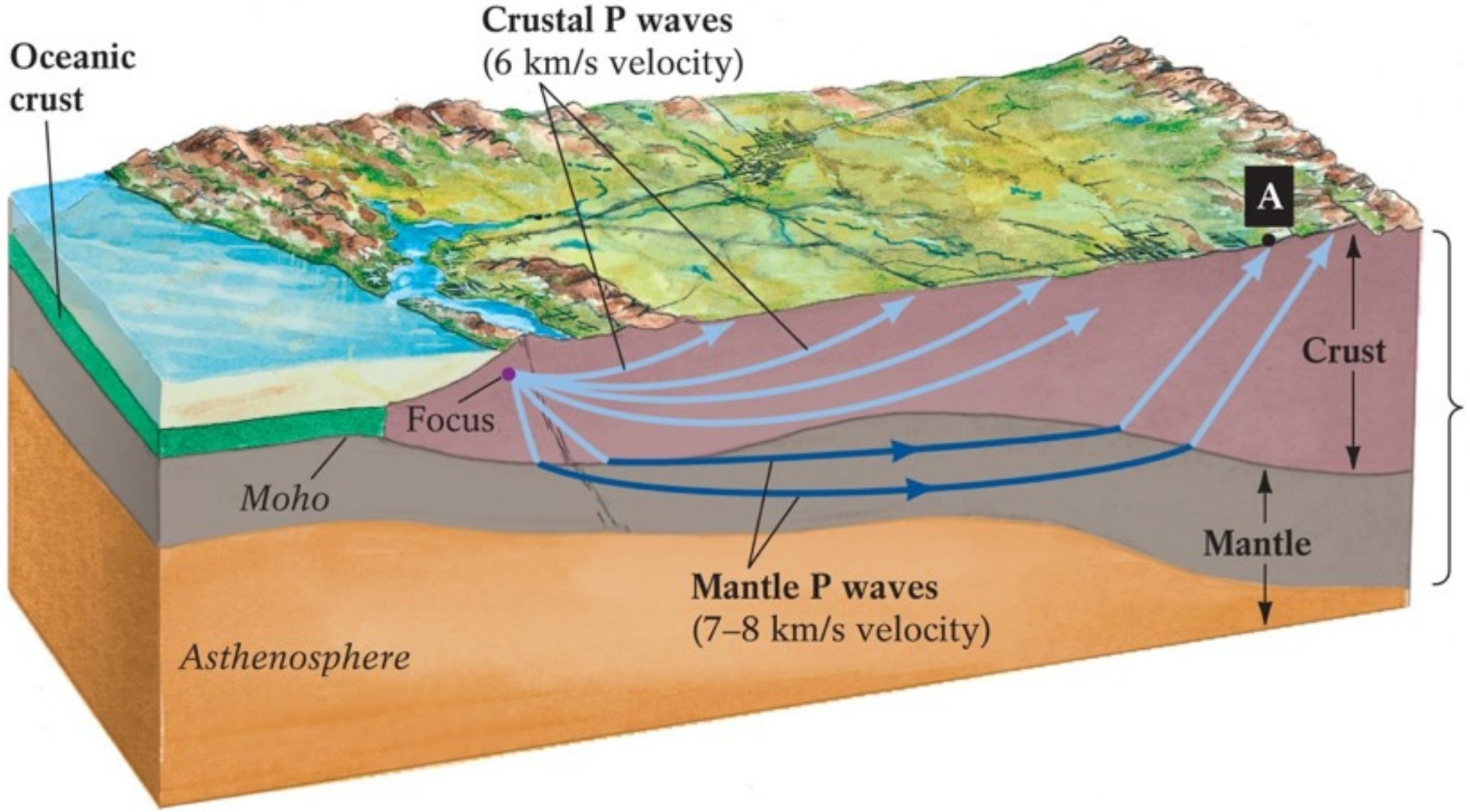
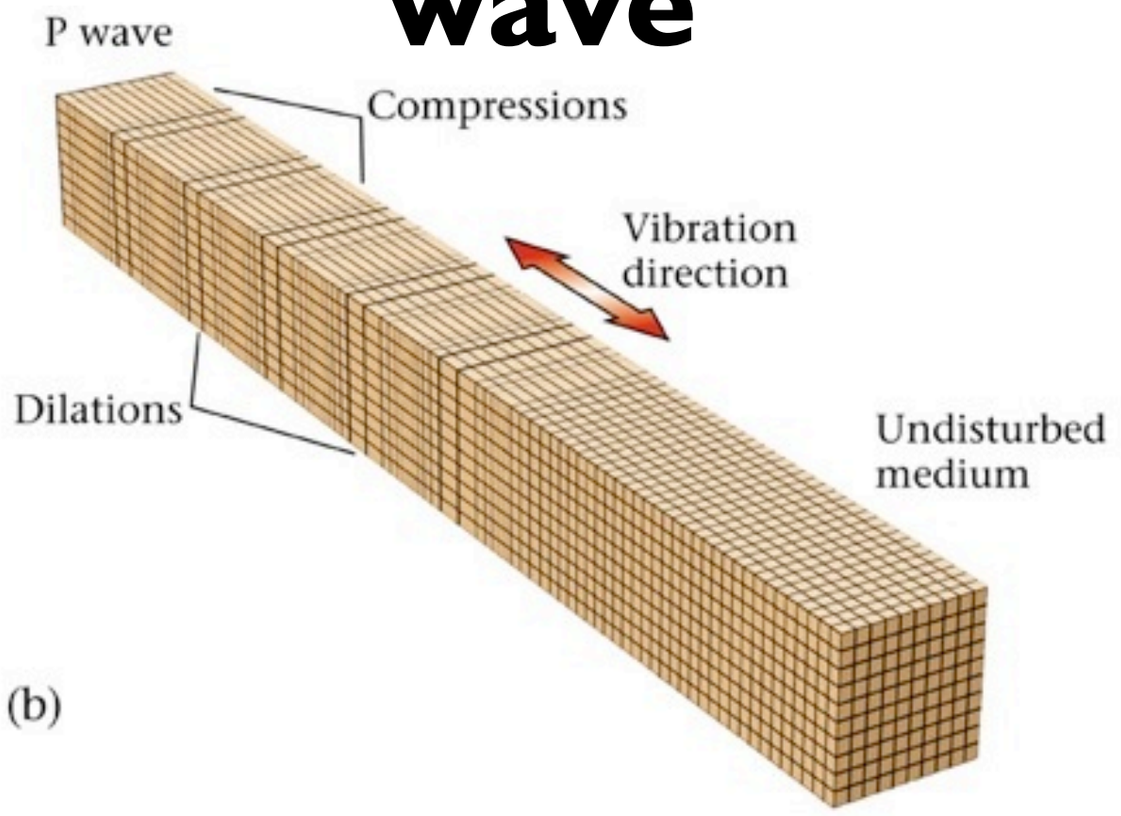
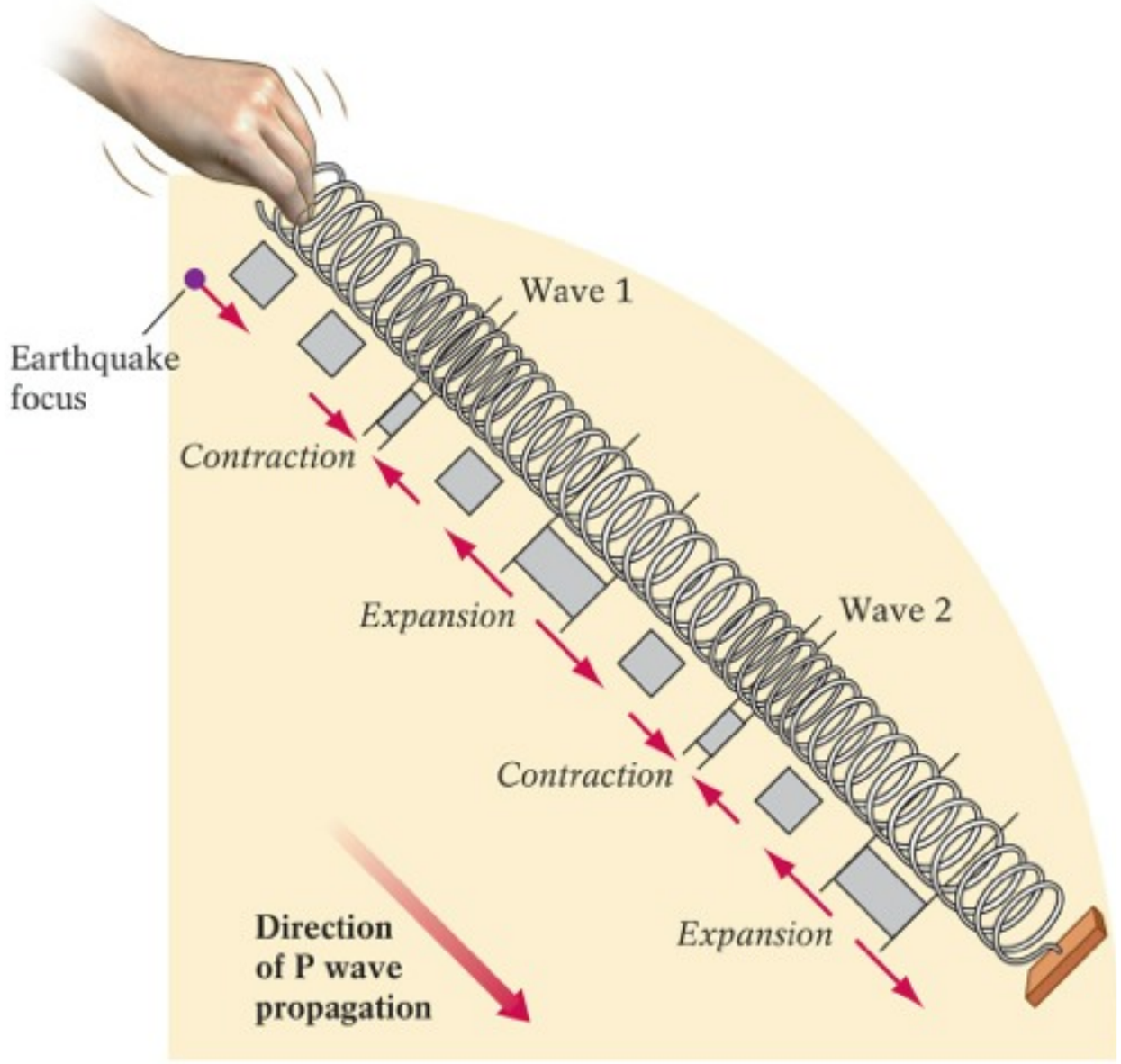


Seismic waves associated with Earthquakes

Name	Type	Propagation	Travels through
P-wave	Compressional ***Body*** wave	particle motion is parallel to wave direction	solids, liquids, and gases

P- waves (Primary) are Compressional wave





1) Body wave travels throughout the body of Earth.

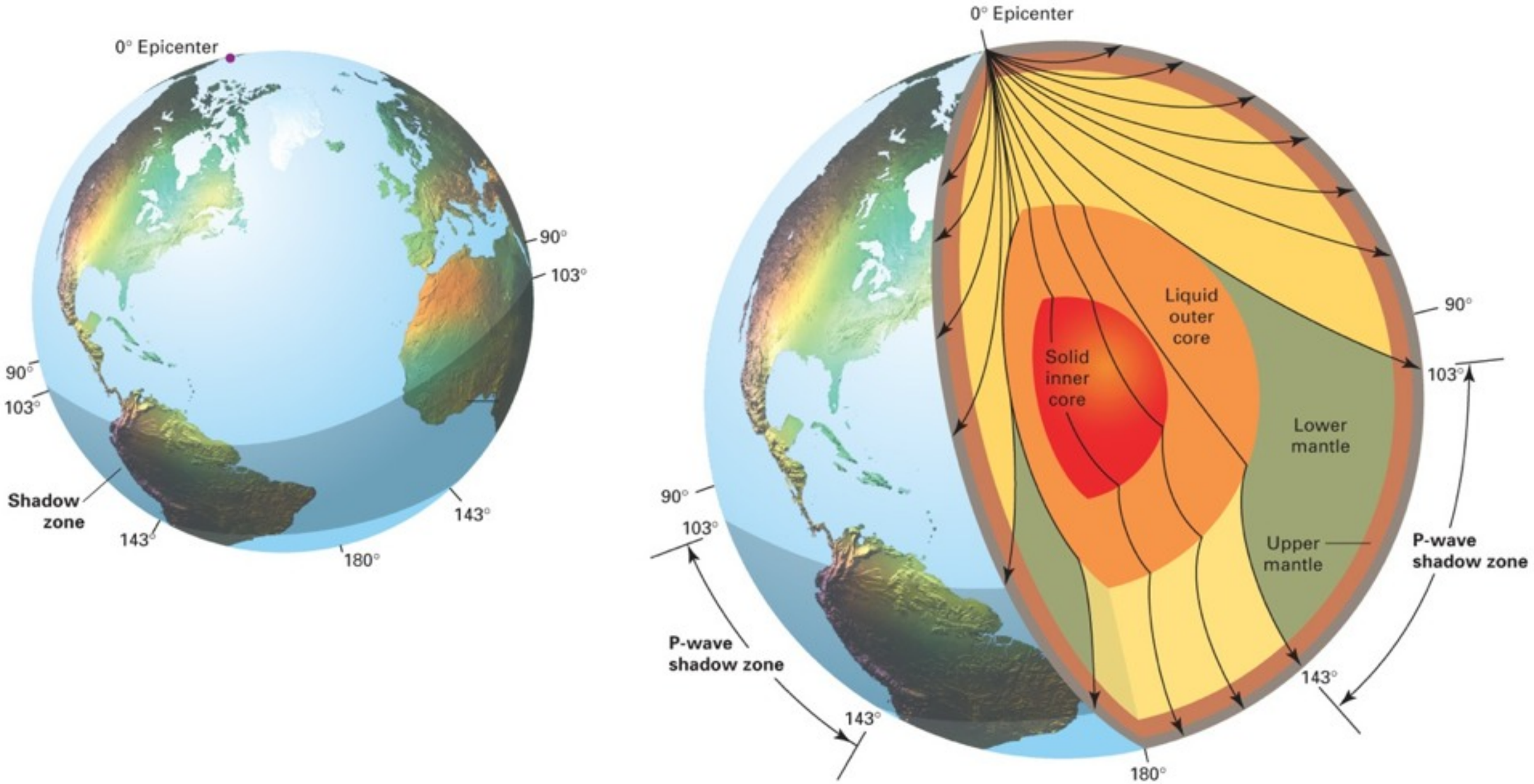
2) Fastest wave- Arrives first following an Earthquake (~6-7 km/s).

3) Compressional wave move particles back and forth parallel to the propagation direction (transport direction).

4) Travels through solids, liquids and gas

P- waves Shadow Zone

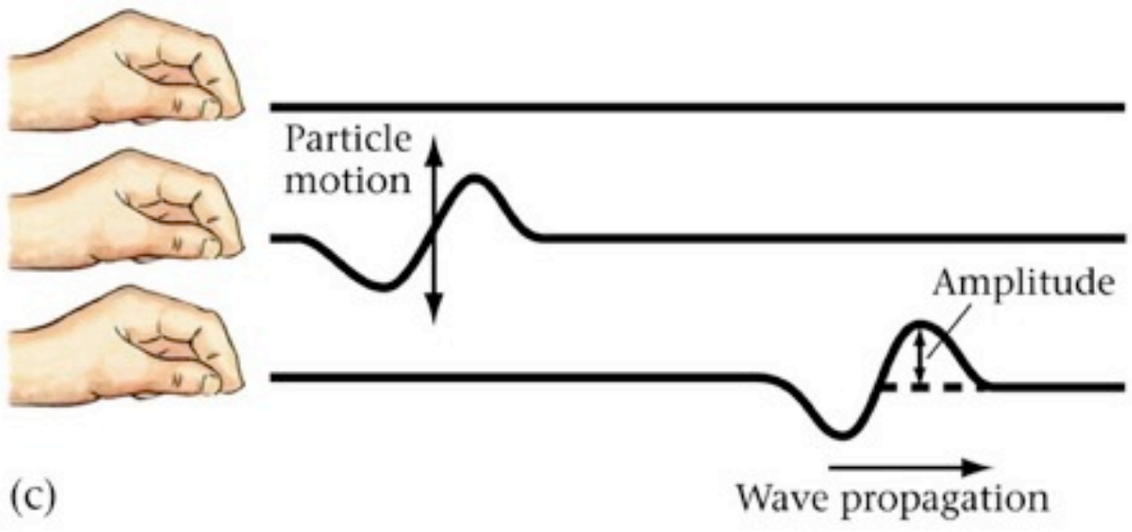
P-wave	Compressional ***Body*** wave	particle motion is parallel to wave direction	solids, liquids, and gases

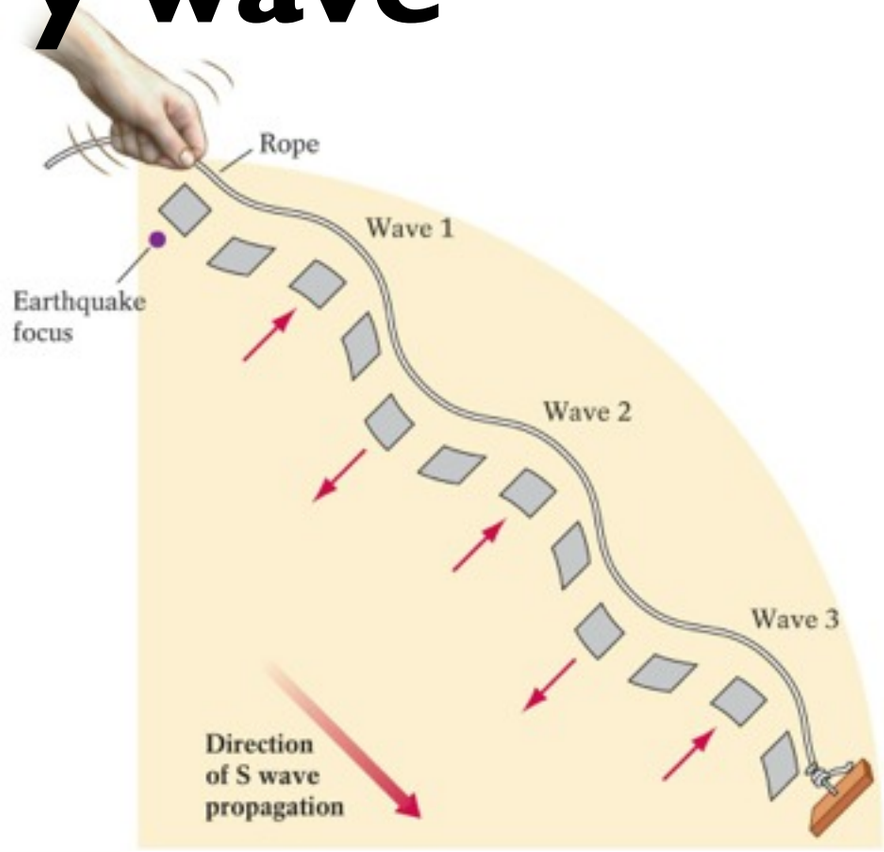


Seismic waves associated with Earthquakes

Name	Type	Propagation	Travels through
P-wave	Compressional ***Body*** wave	particle motion is parallel to wave direction	solids, liquids, and gases
S-wave	Shear ***Body*** wave	particle motion is vertical and perpendicular to direction	solids

S - waves
Shear or Secondary wave

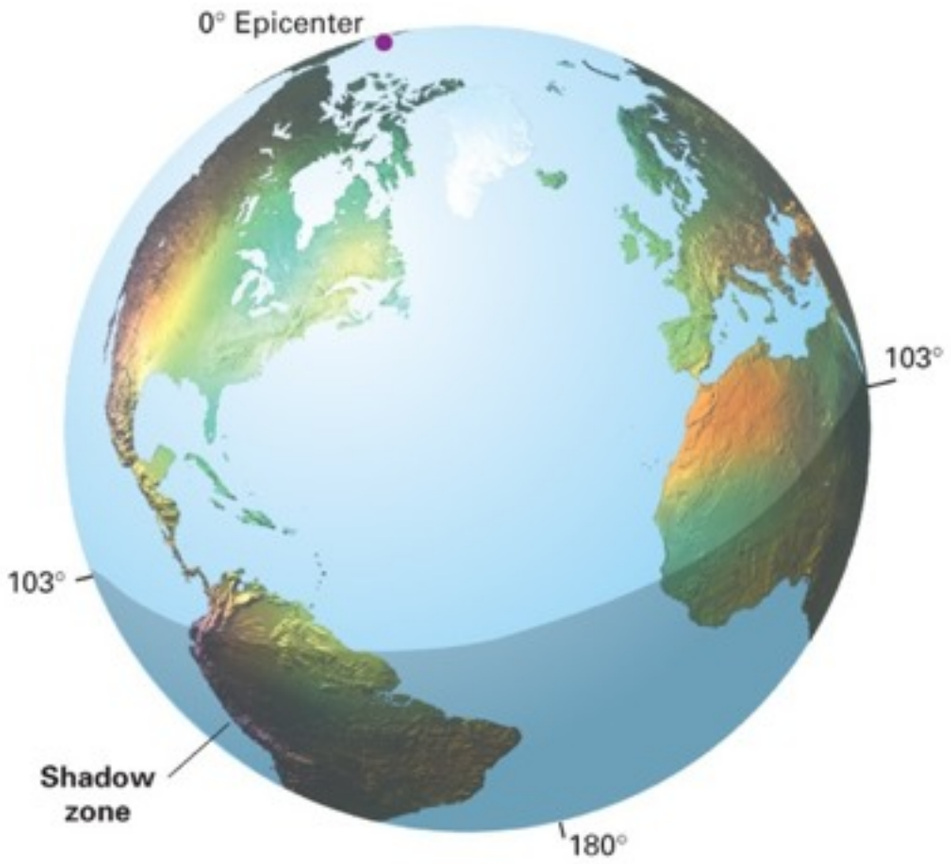


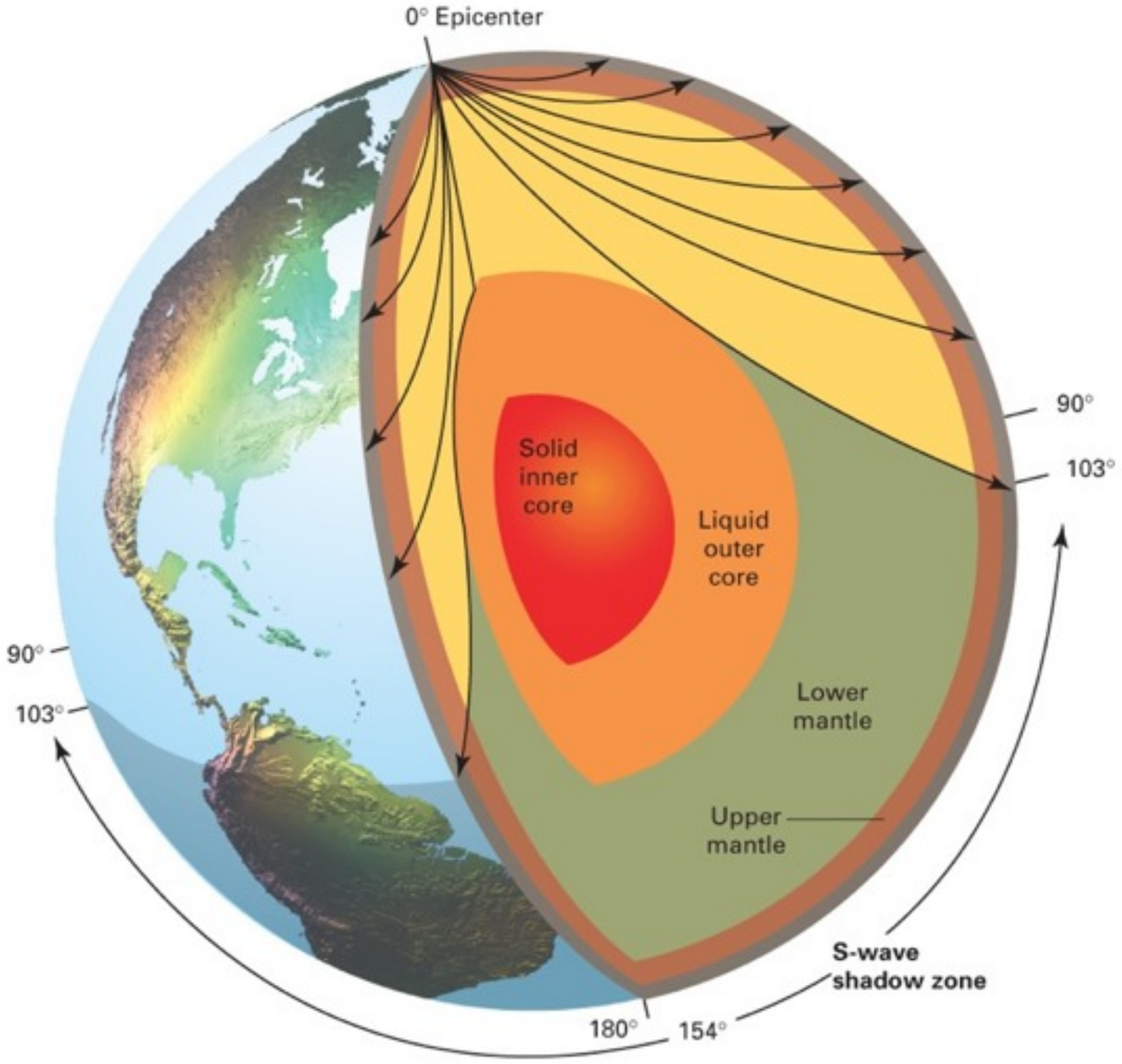


1) Body wave travels throughout most of the body of Earth
2) 2nd fastest wave- Arrives second following an EQ (~3.5 km/s)
3) Shear waves move particles is a vertical (up and down) motion perpendicular to the propagation direction (transport direction)
4) Travels through solids only

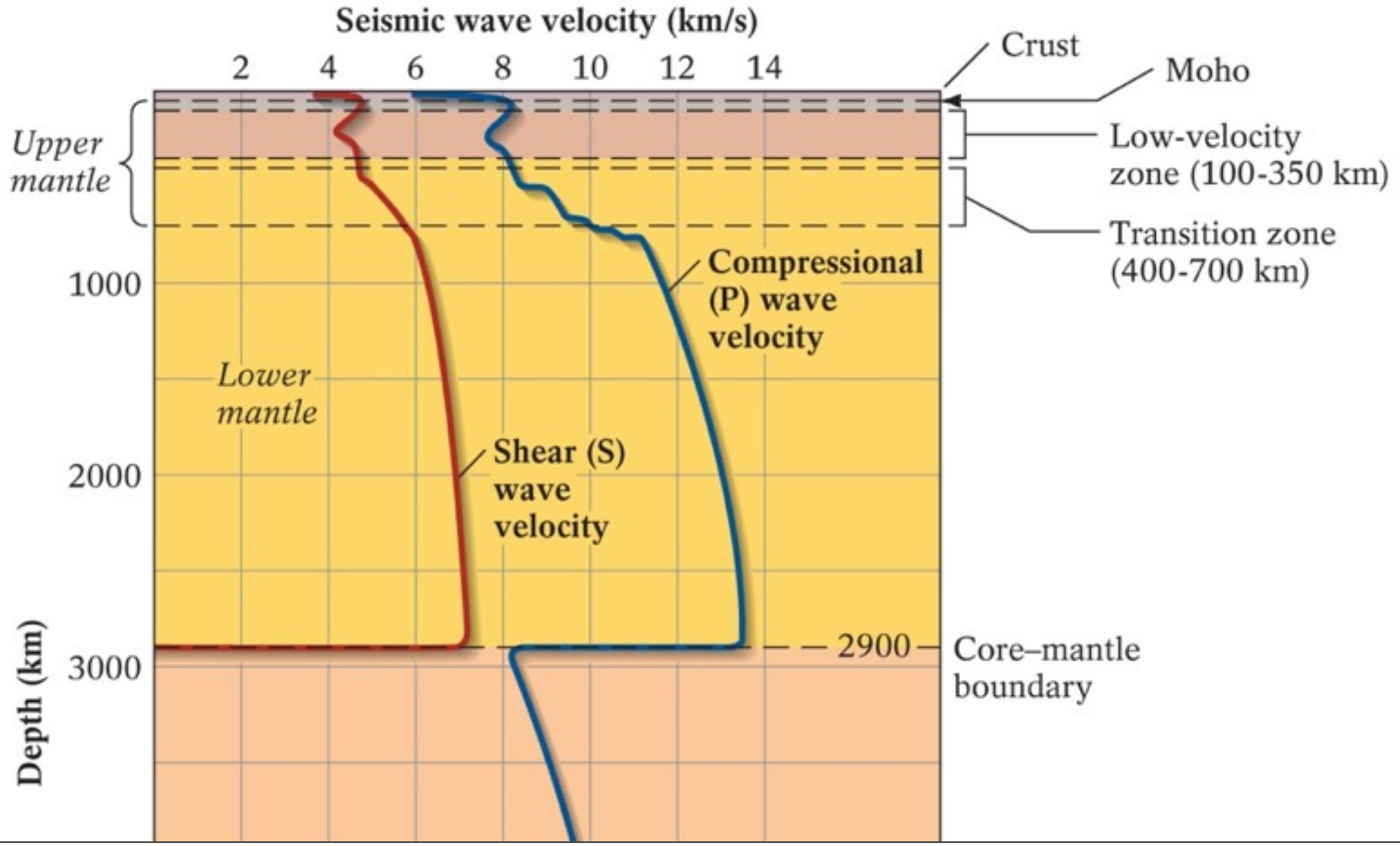
S- waves Shadow Zone

S-wave	Shear ***Body*** wave	particle motion is vertical and perpendicular to direction	solids





Name	Type	Propagation	Travels through
P-wave	Compressional ***Body*** wave	particle motion is parallel to wave direction	solids, liquids, and gases
S-wave	Shear ***Body*** wave	particle motion is vertical and perpendicular to direction	solids

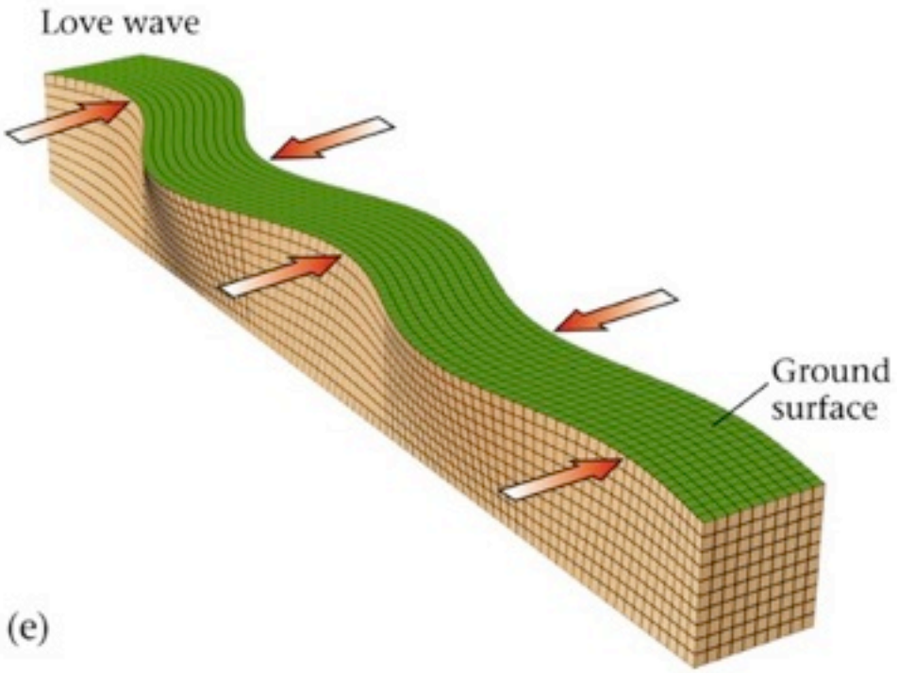


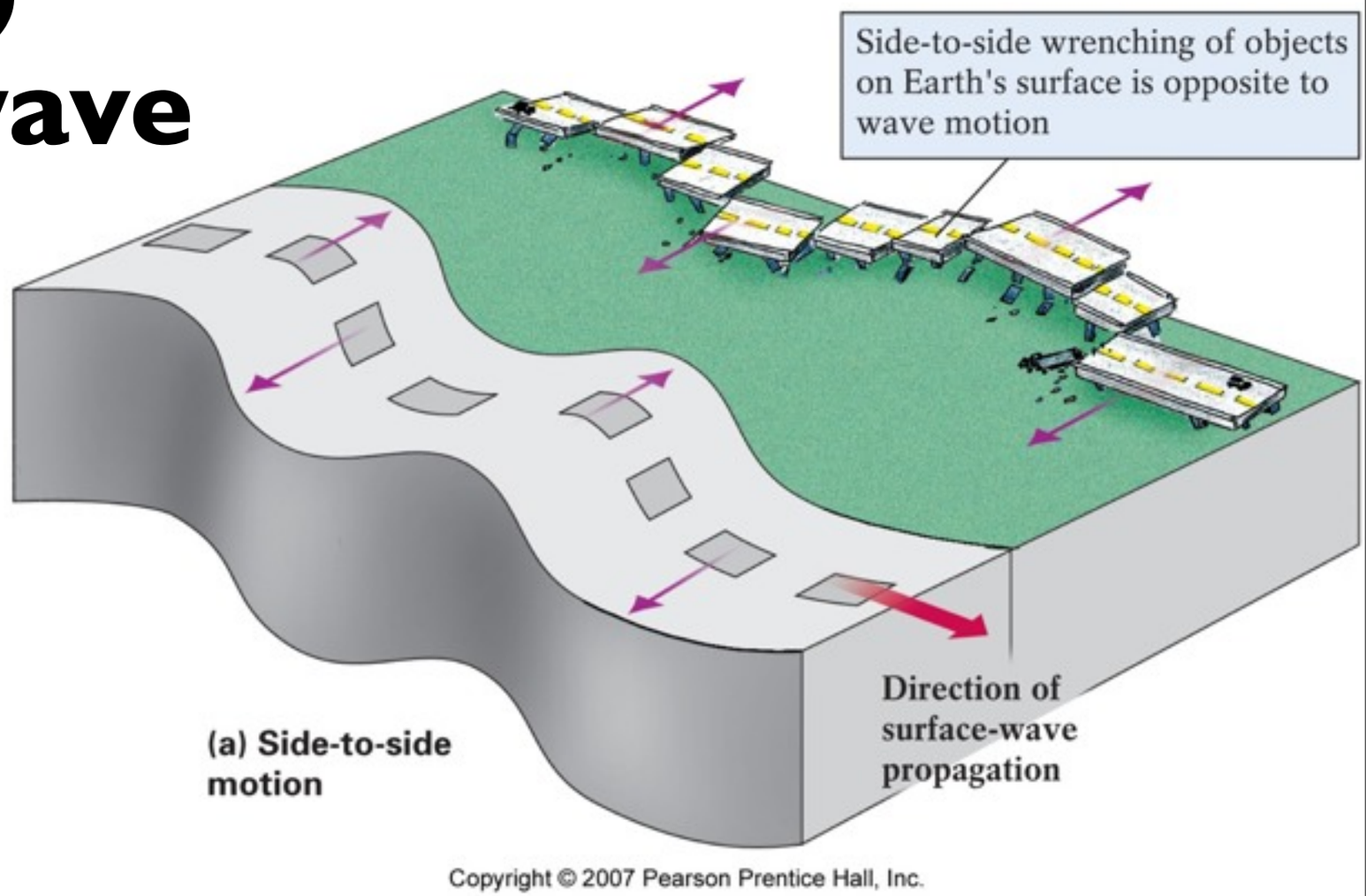
Seismic waves associated with Earthquakes

Name	Type	Propagation	Travels through
P-wave	Compressional ***Body*** wave	particle motion is parallel to wave direction	solids, liquids, and gases
S-wave	Shear ***Body*** wave	particle motion is vertical and perpendicular to direction	solids

Love wave	Shear ***Surface*** wave	particle motion is horizontal and perpendicular to	solids

L - waves (Love)
Surface Shear wave



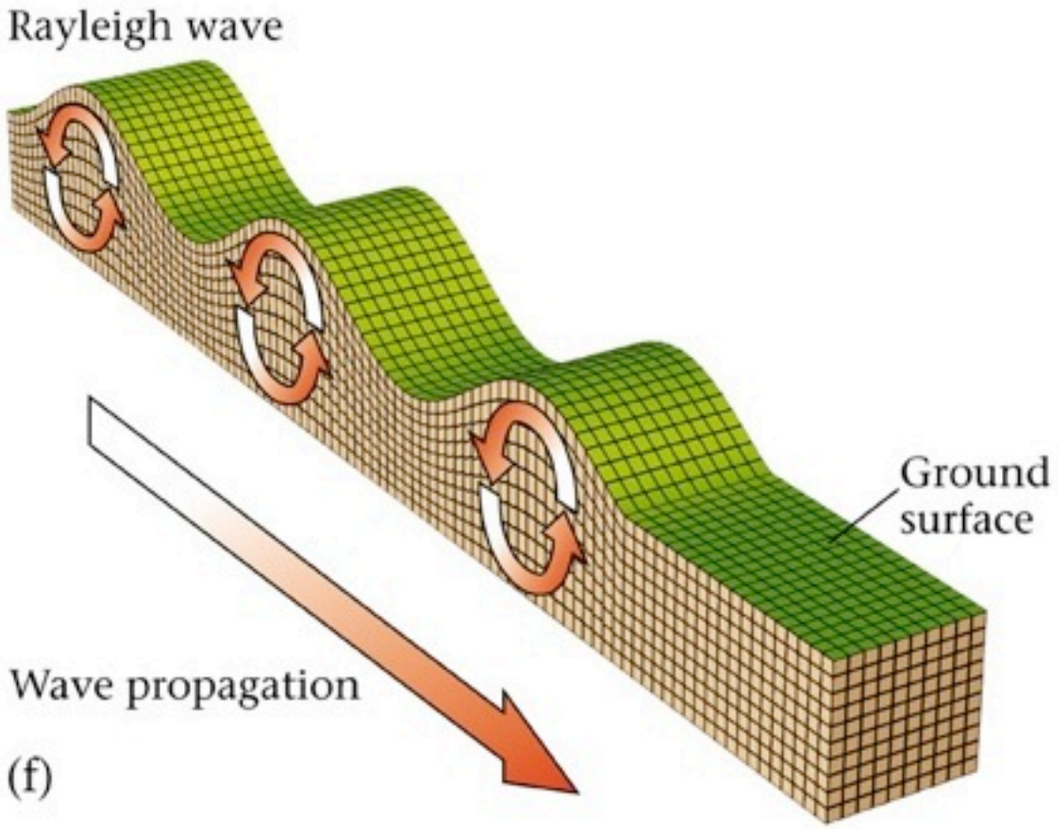


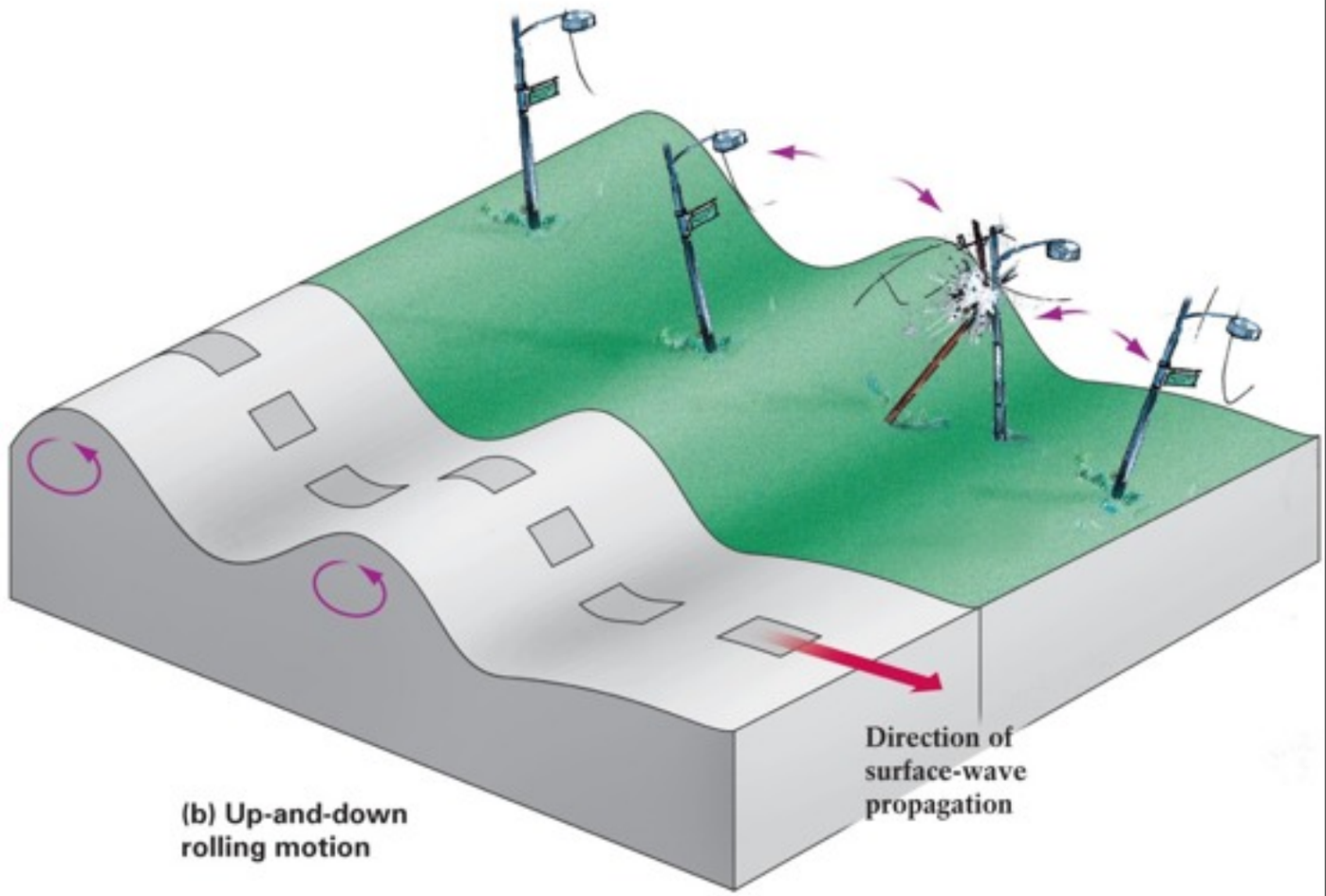
1) Surface wave - Refractory wave that moves through the surface
2) Shear wave propagates perpendicular to transport and parallel to the ground surface
3) Travels through solids only

Seismic waves associated with Earthquakes

Name	Type	Propagation	Travels through
P-wave	Compressional ***Body*** wave	particle motion is parallel to wave direction	solids, liquids, and gases
S-wave	Shear ***Body*** wave	particle motion is vertical and perpendicular to direction	solids
Love wave	Shear ***Surface*** wave	particle motion is horizontal and perpendicular to	solids
Rayleigh wave	Orbital ***Surface*** wave	particle motion is circular	solids and liquids

Rayleigh waves are Rotational or Orbital wave

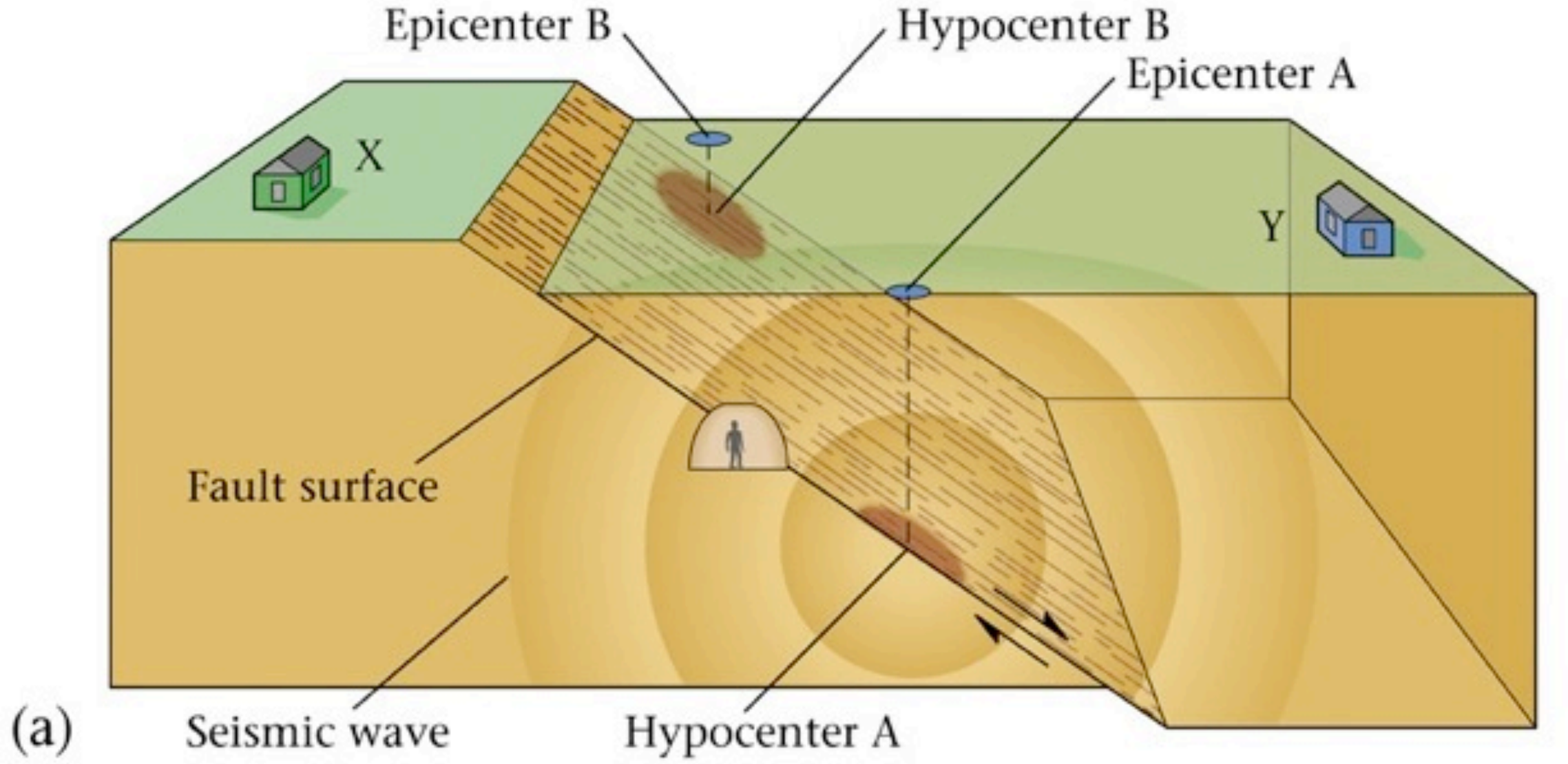




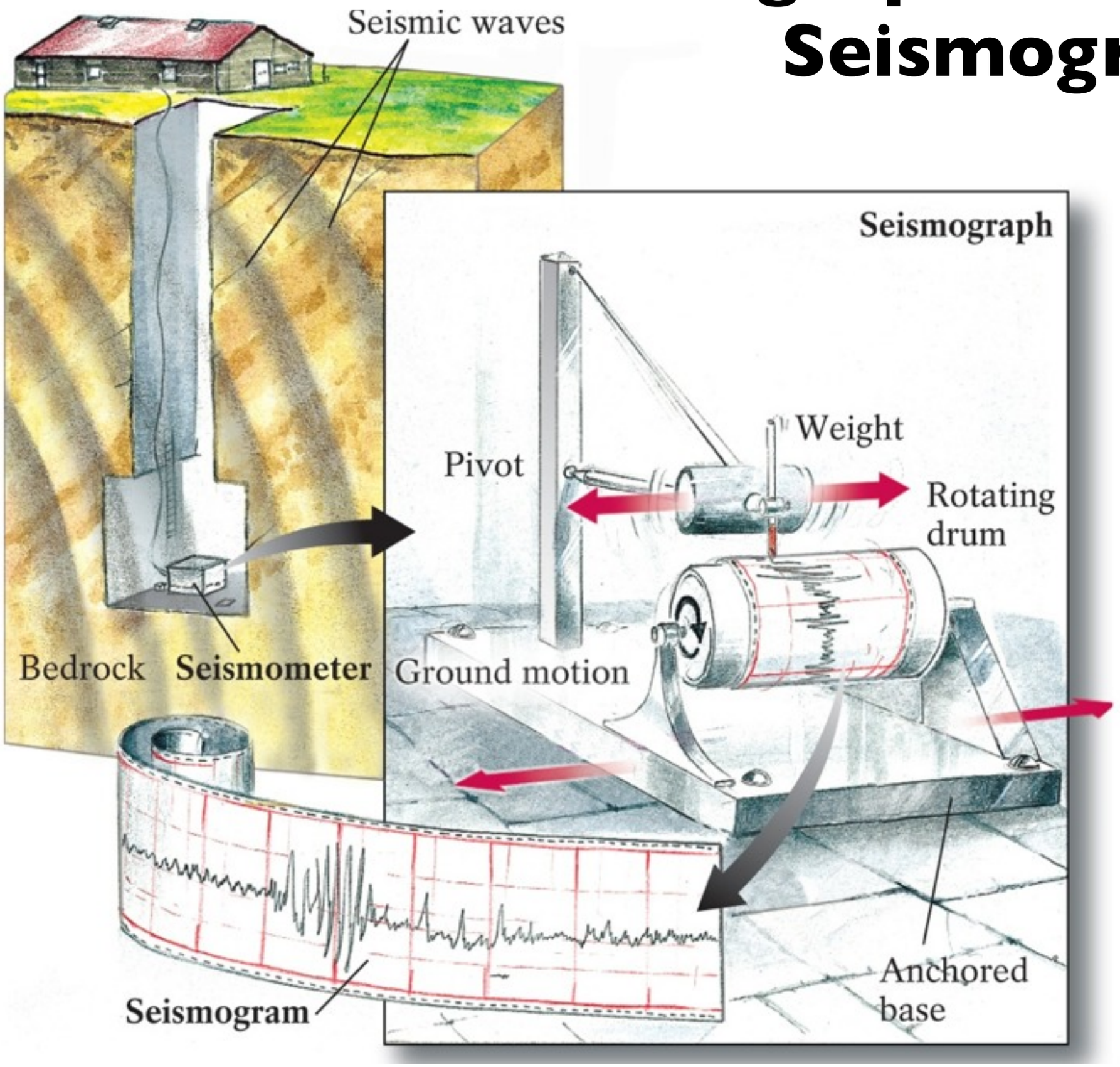
1) Surface wave-Refractory wave that moves through the surface
2) Rotational wave- Combination of compressional and shear wave
3) Travels through solids and liquids

Seismic waves associated with Earthquakes

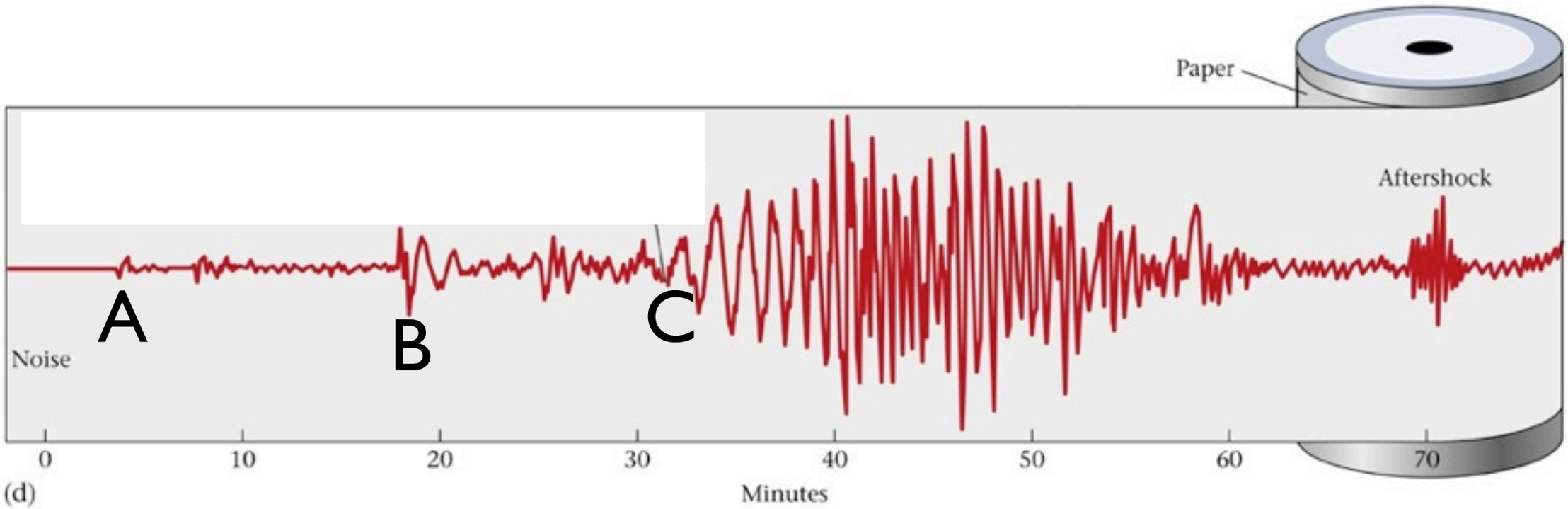
Elastic Energy Release and Non-recoverable brittle strain



Seismograph records onto a Seismogram

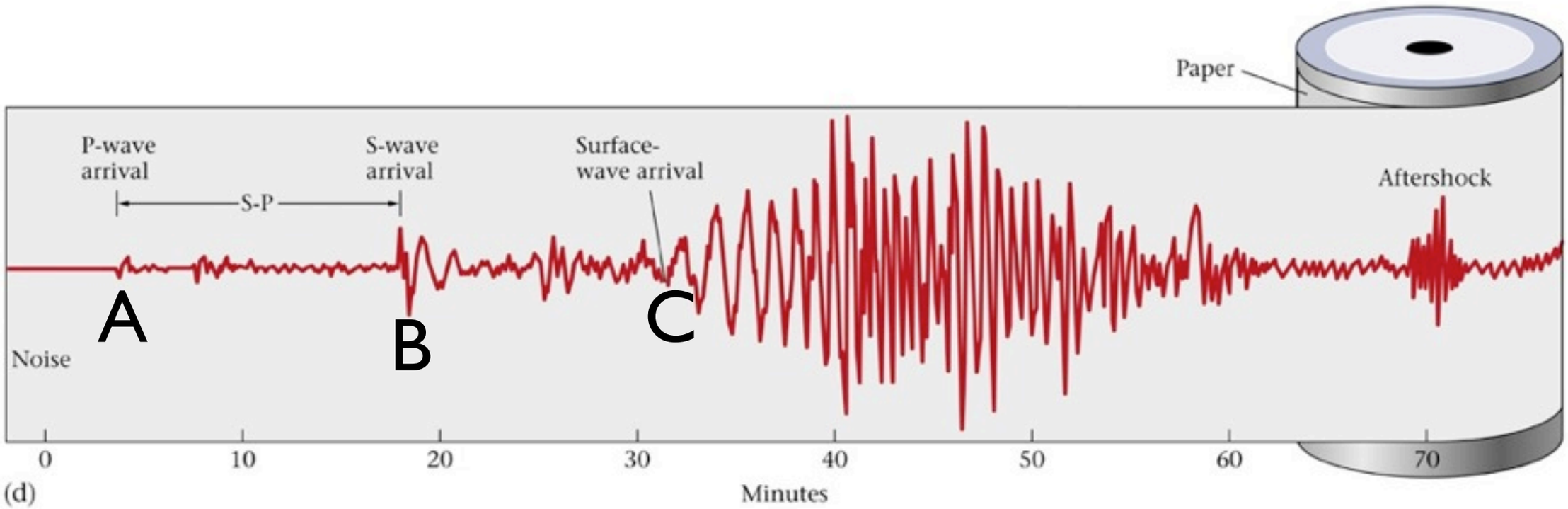


Detailed Seismogram



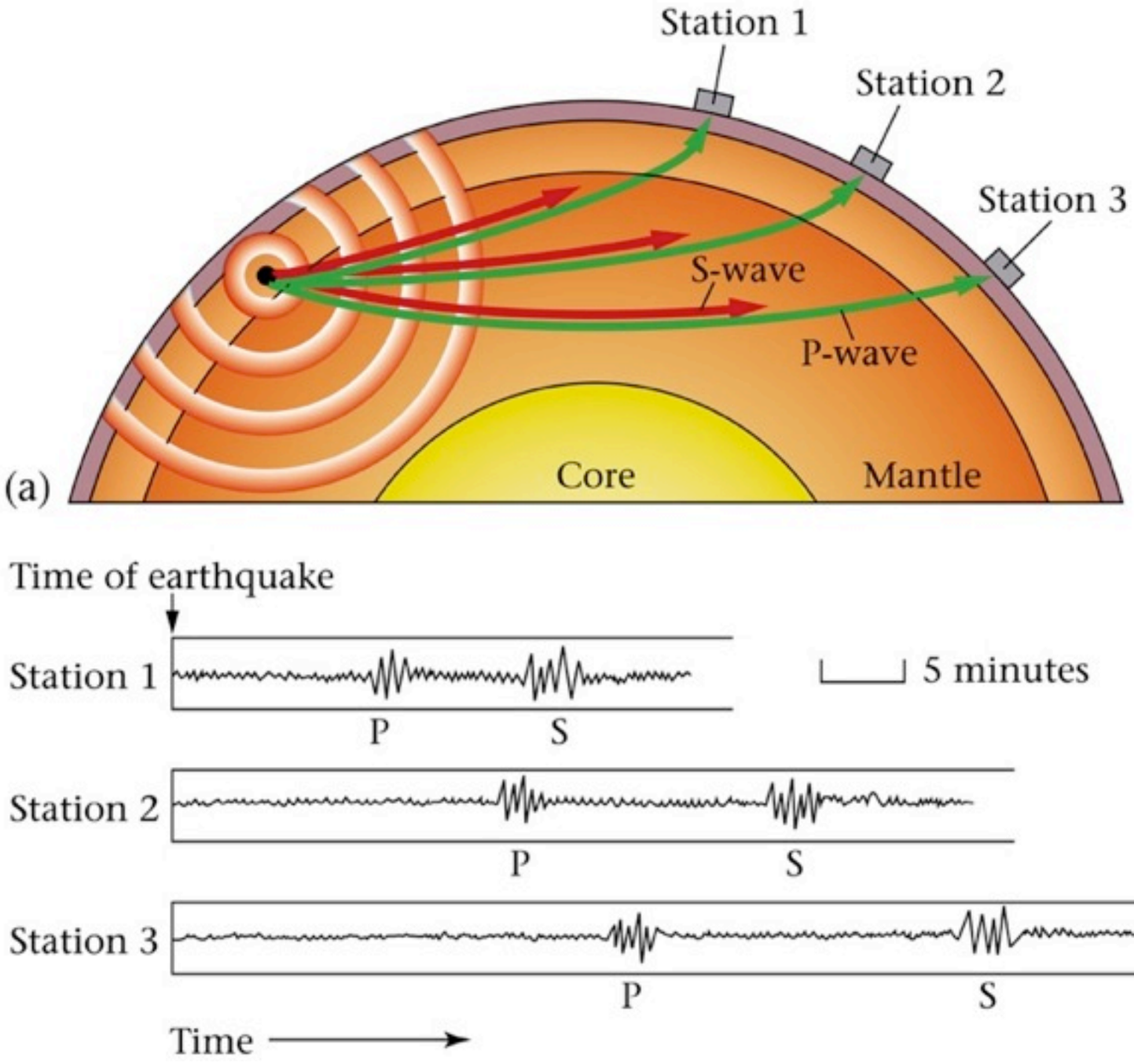
(d)

Detailed Seismogram

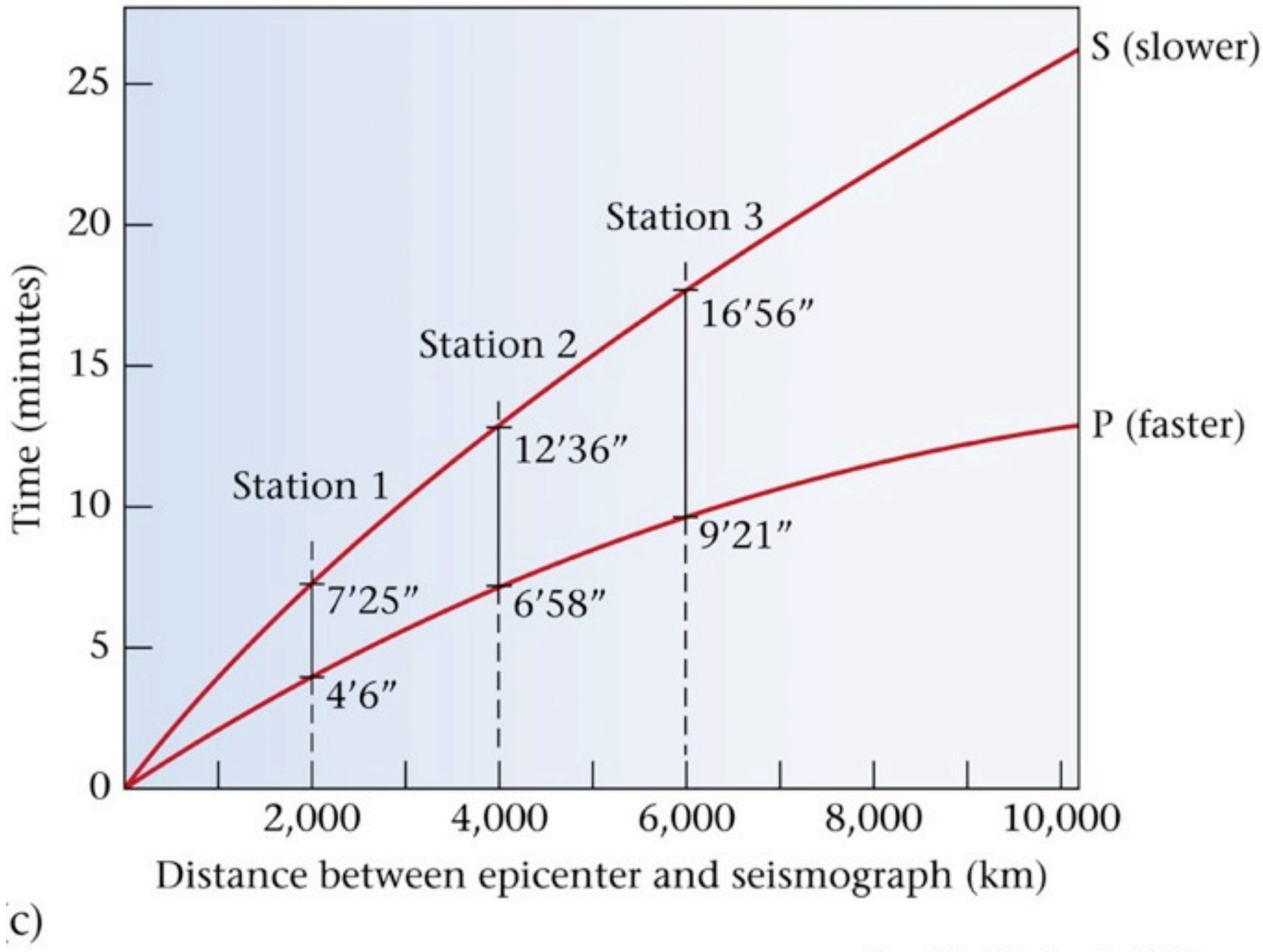


(d)

Time-lag between P and S wave changes with distance



Time-lag between P and S wave changes with distance



c)

Calculating the Distance to an Earthquake

$$D = \Delta t \times \left(\frac{v_p \times v_s}{v_p - v_s} \right)$$

D is distance

dt is time difference between p and s-wave arrivals

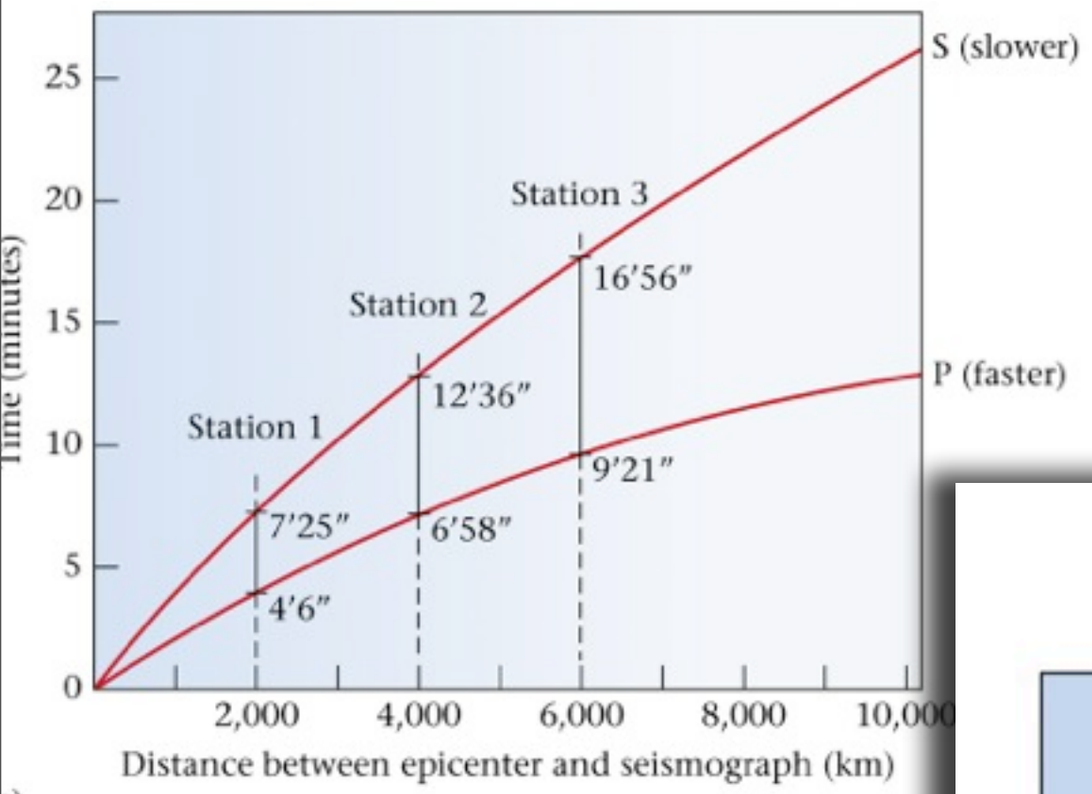
V_p is the velocity of p-wave

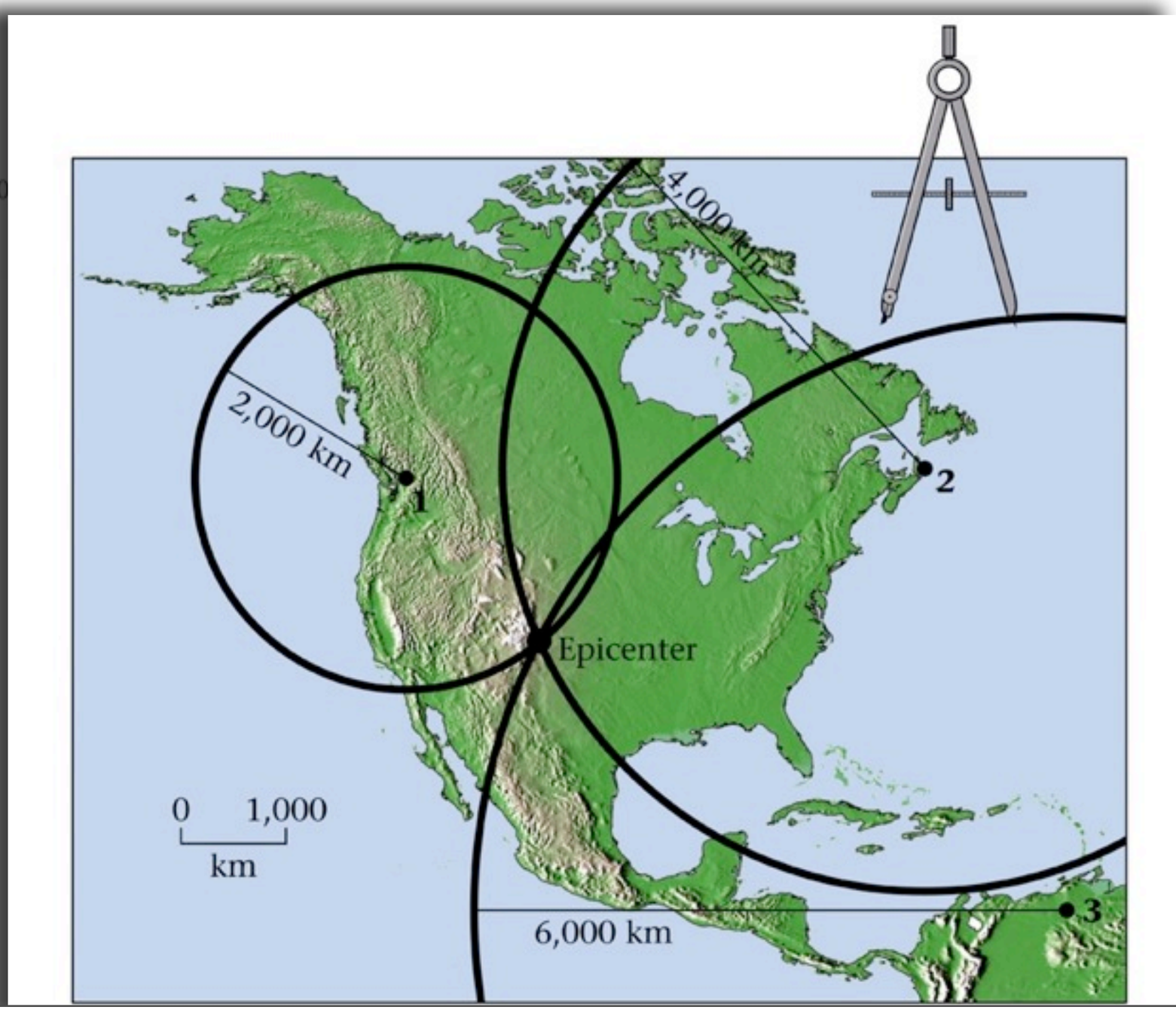
V_s is the velocity of s-wave

Vp = 6 km/s

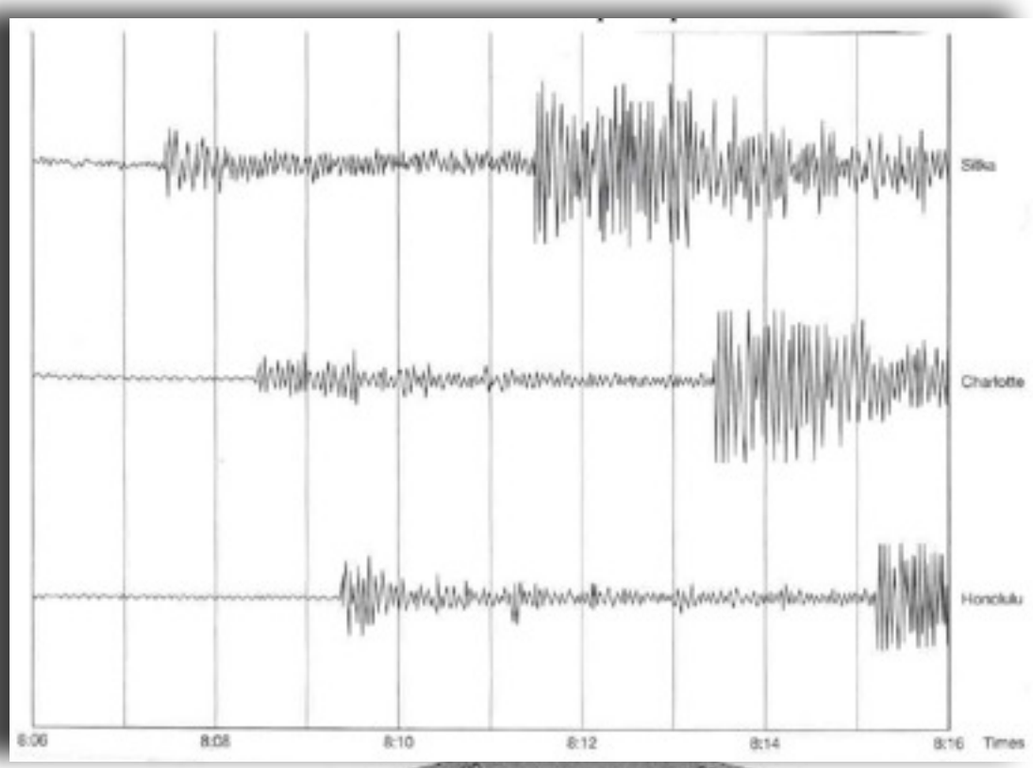
Vs= 3 km/s

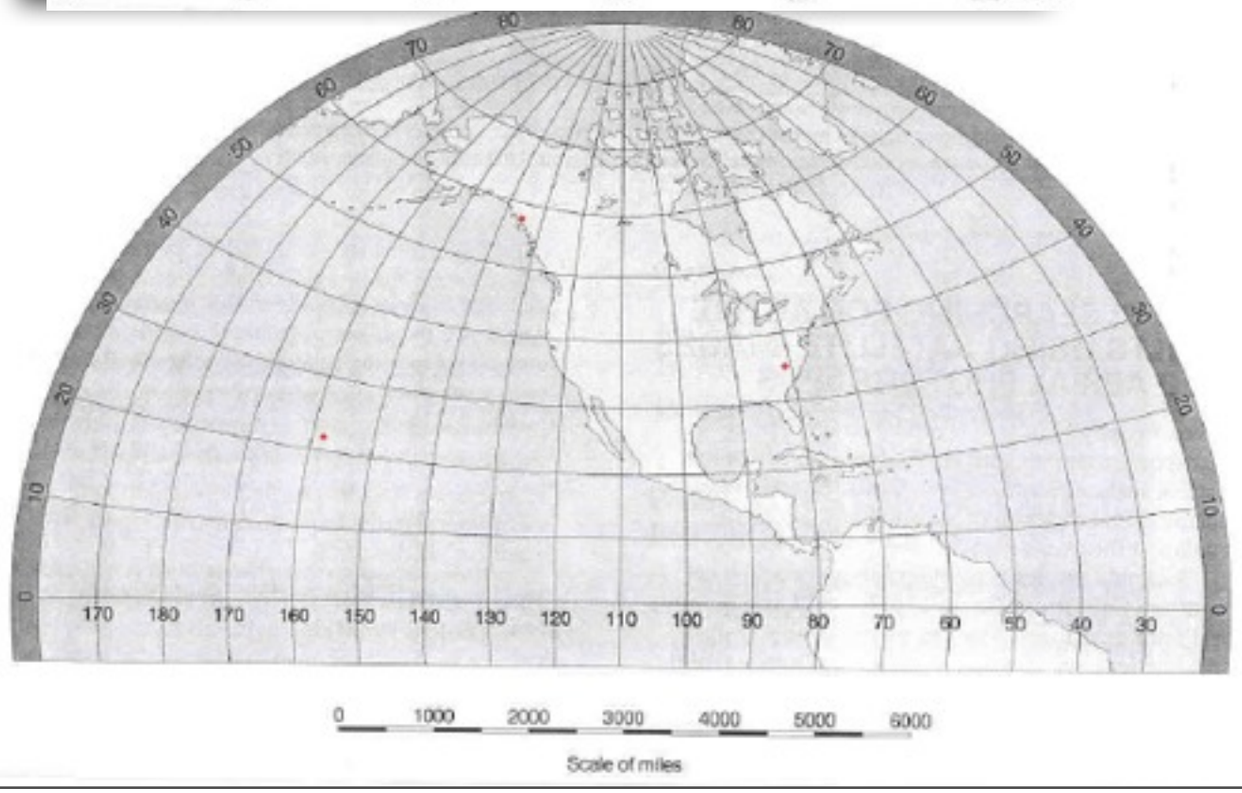
Locating an Earthquake

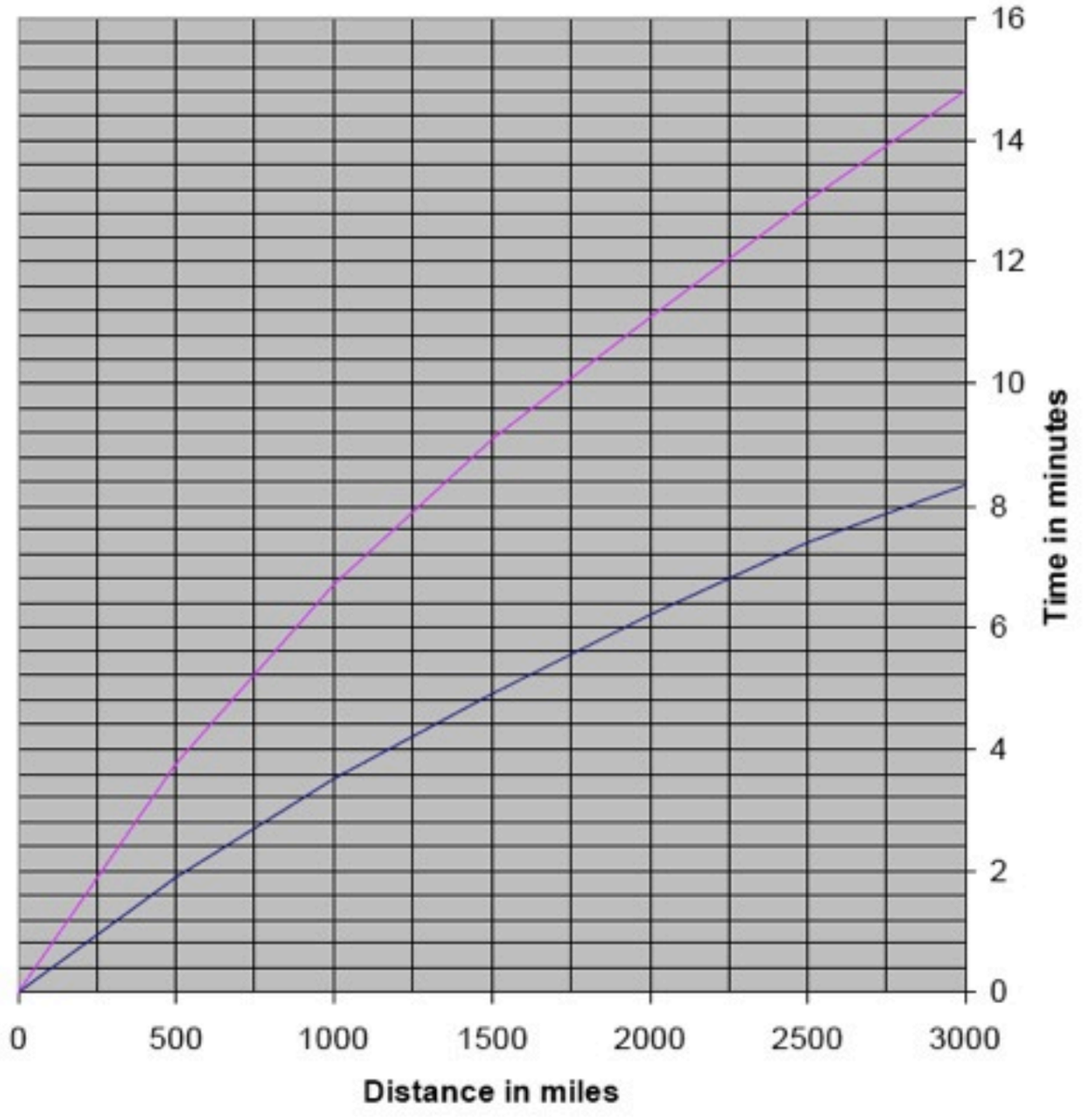




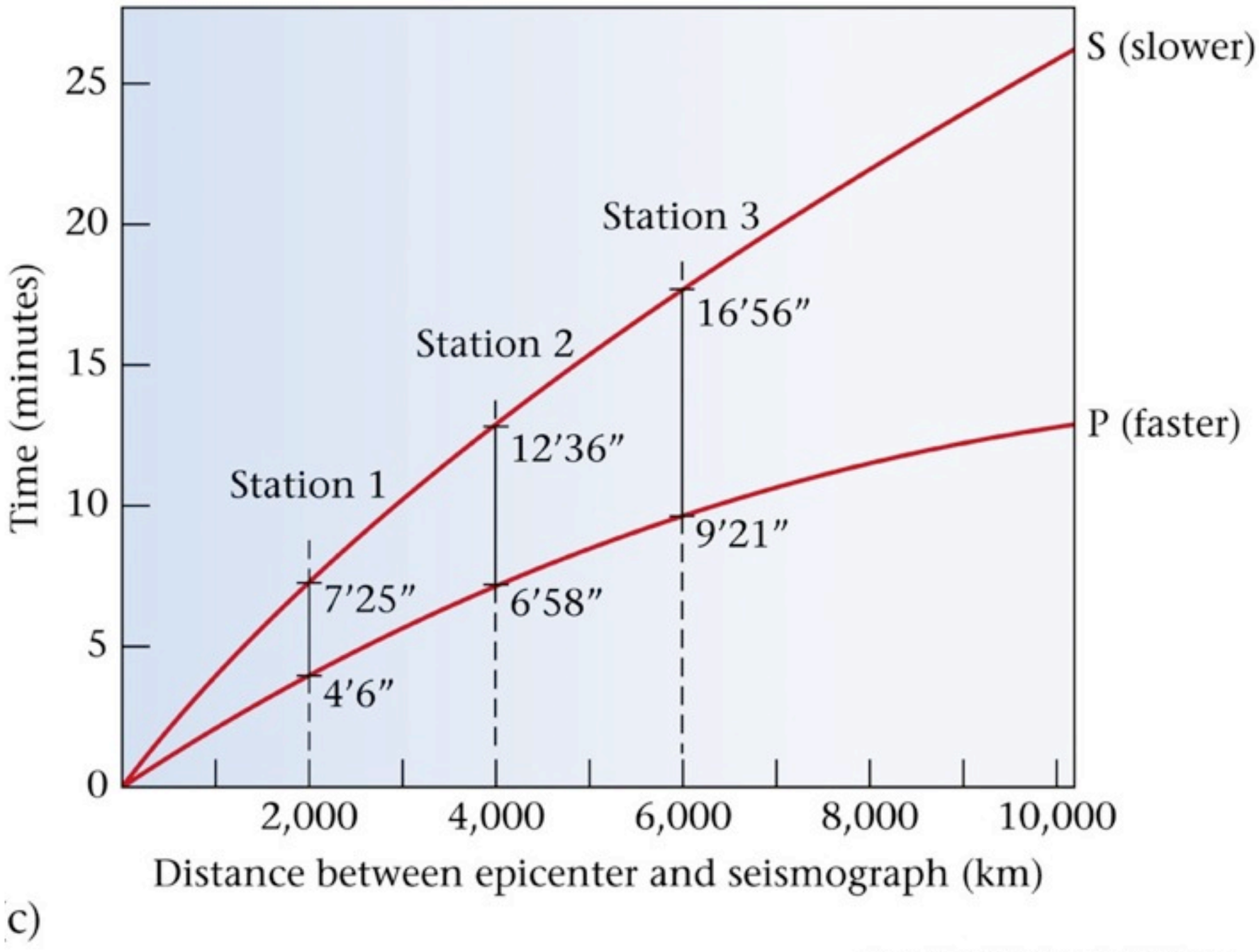
Locating an Earthquake:
10 to 15 minute, In class exercise





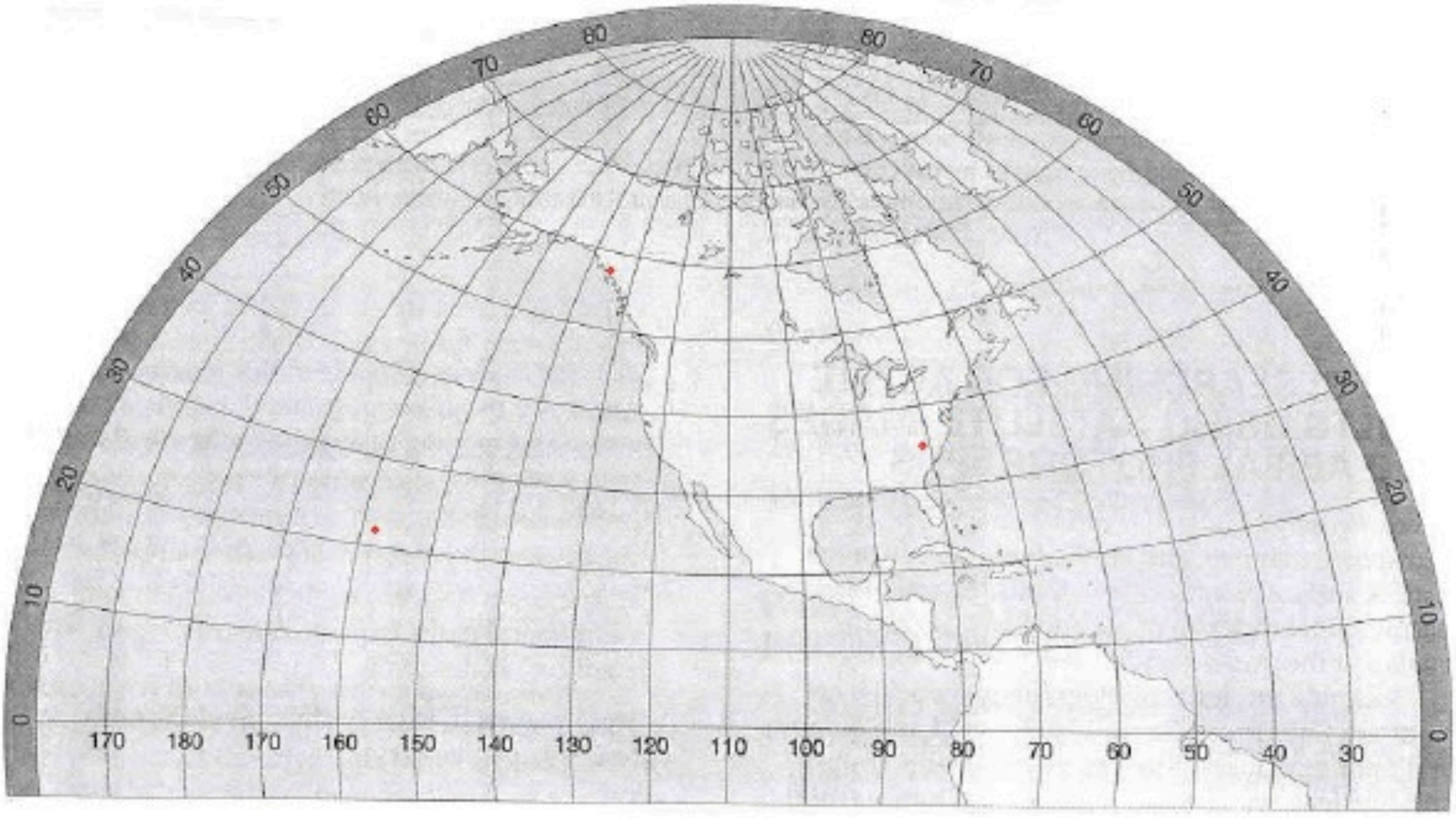


Locating an Earthquake:
10 to 15 minute, In class exercise

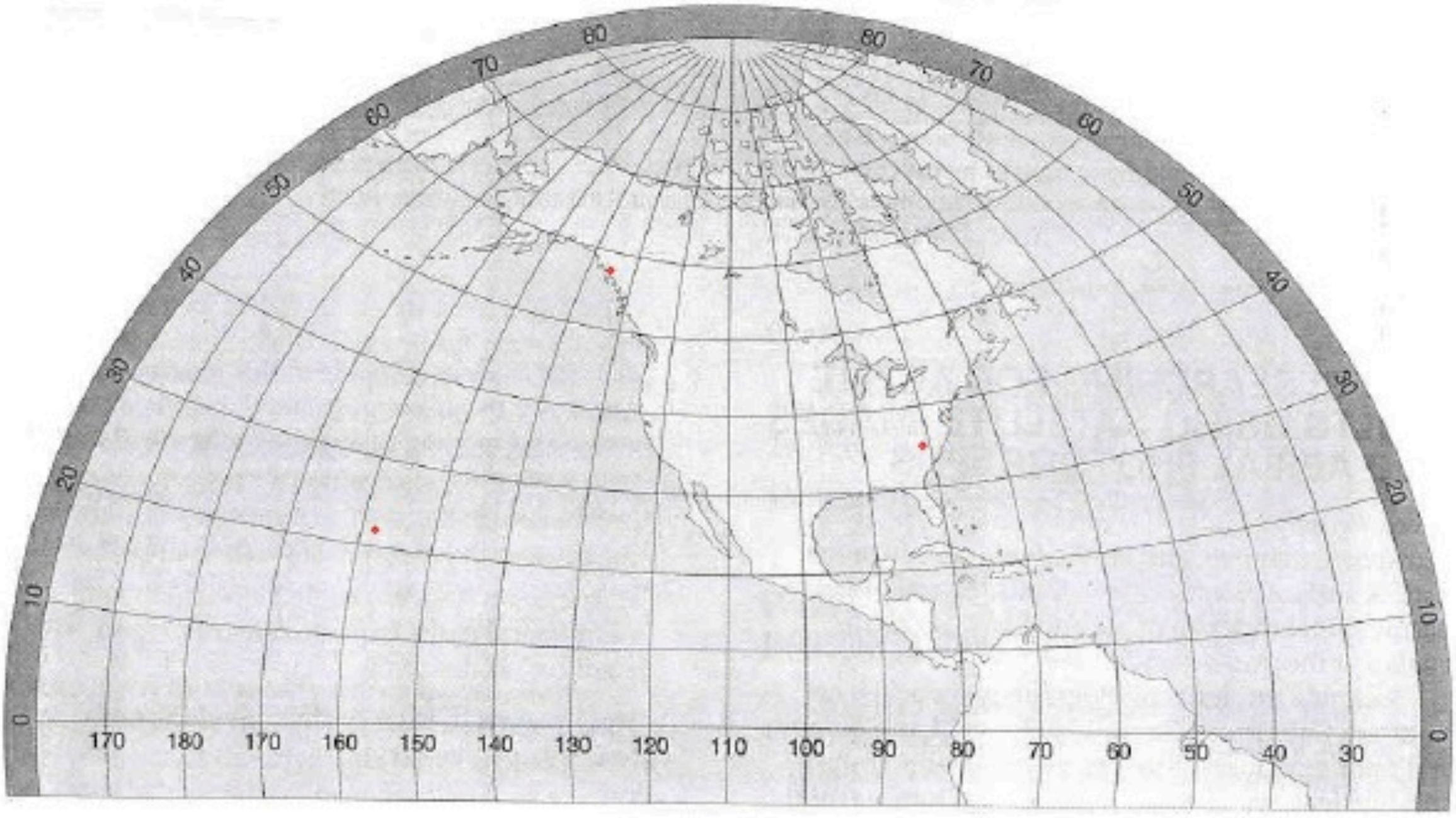


c)

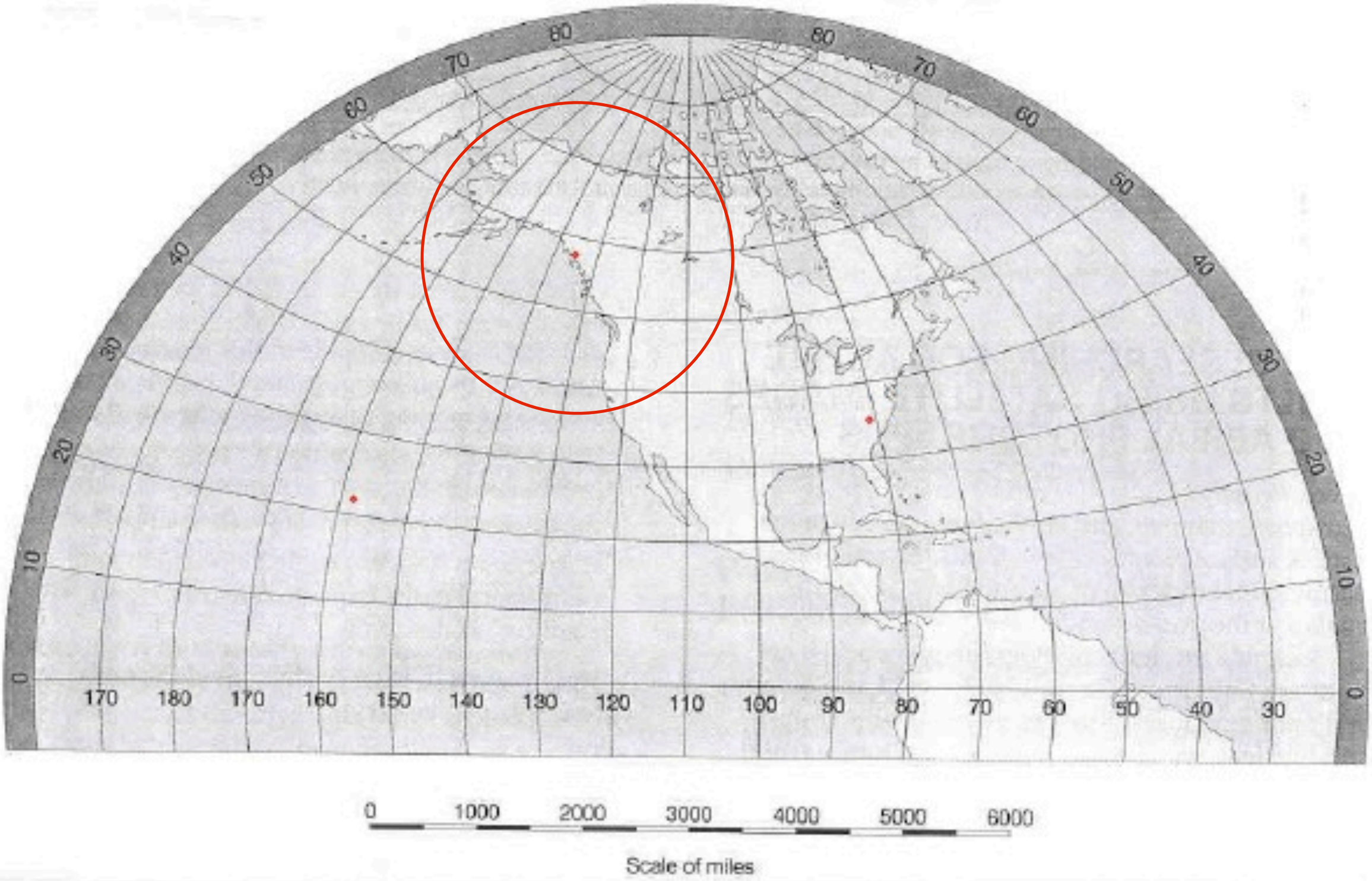
Locating an Earthquake:
10 to 15 minute, In class exercise



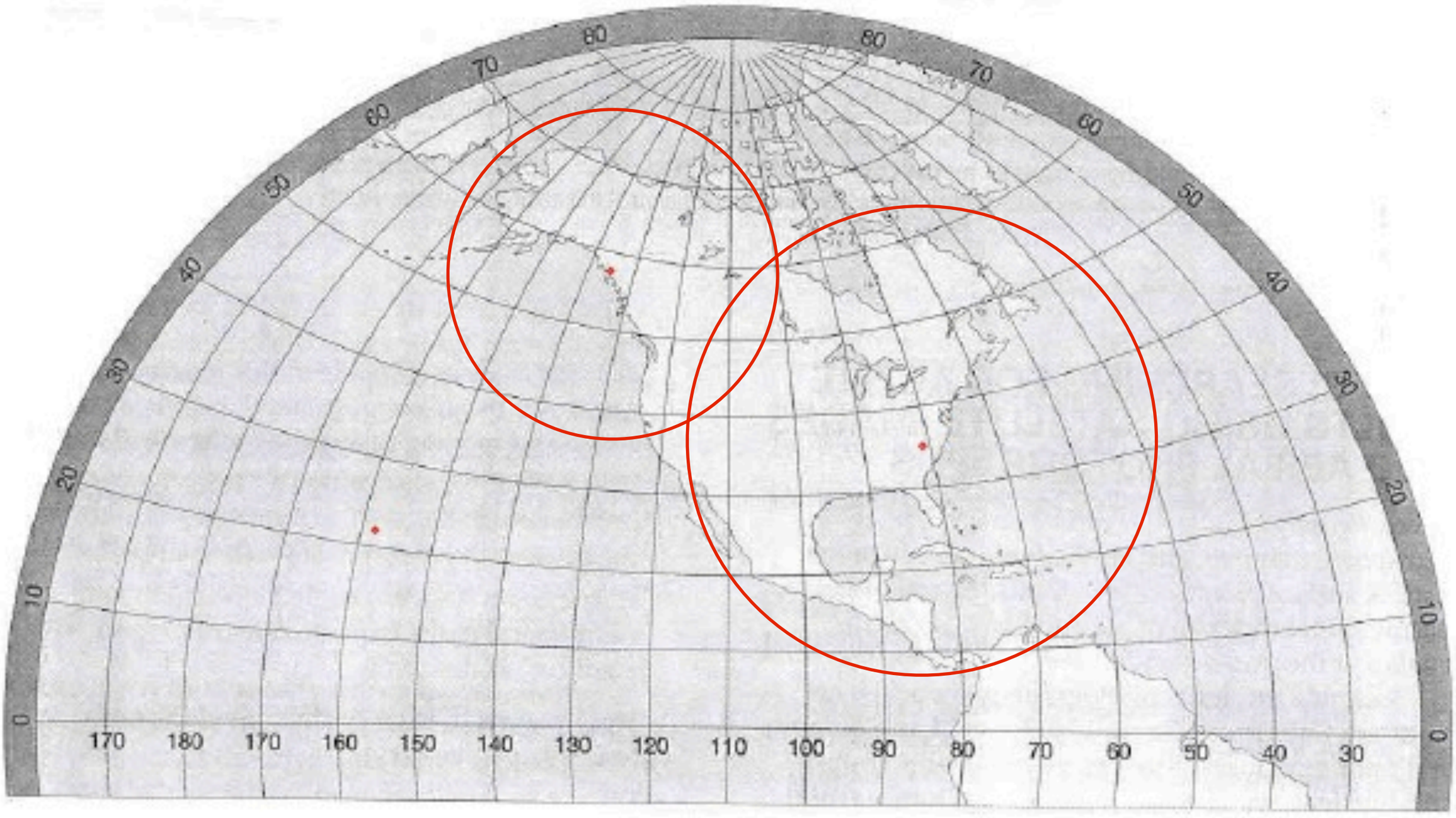
Locating an Earthquake:
10 to 15 minute, In class exercise



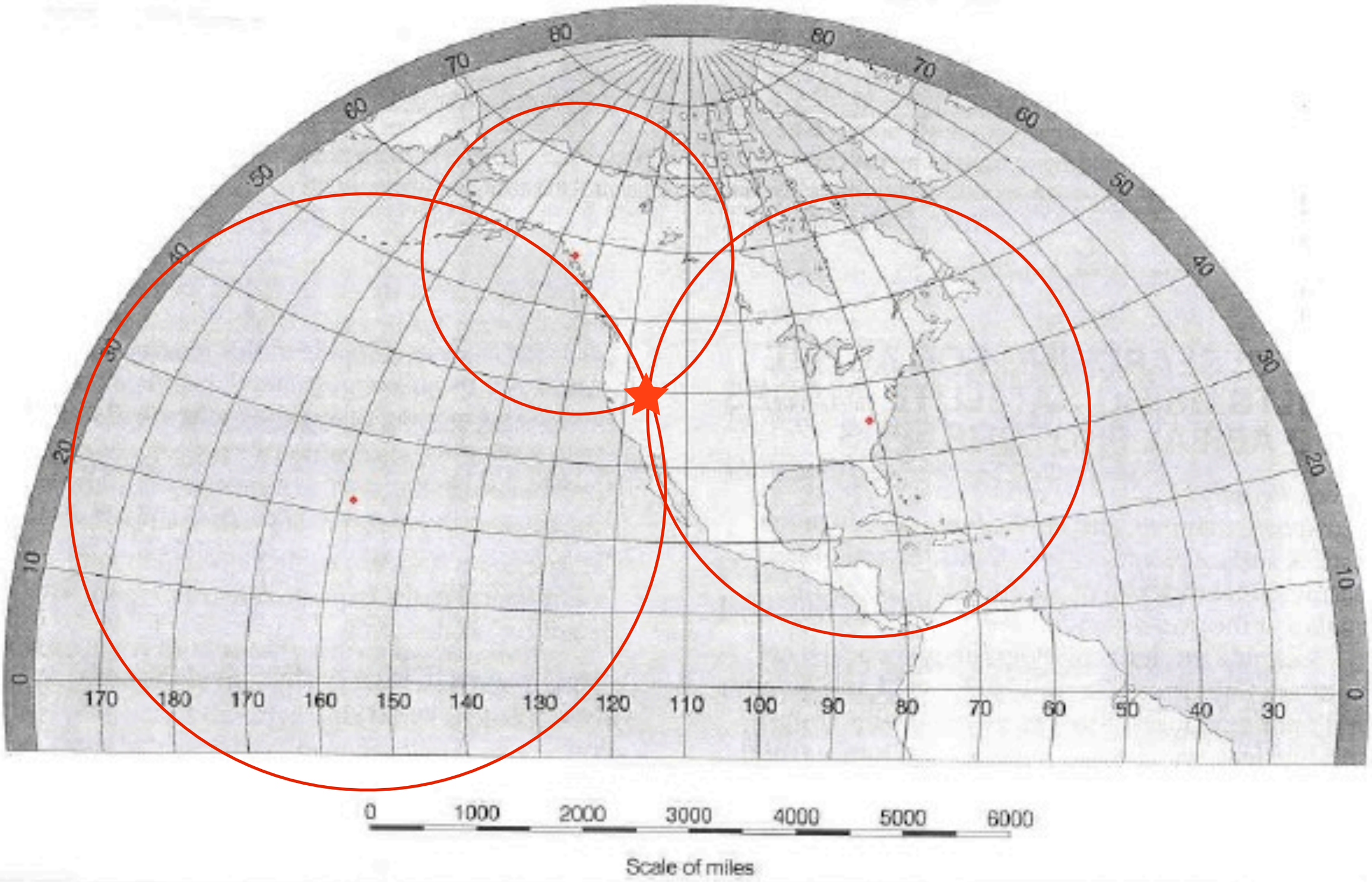
Locating an Earthquake:
10 to 15 minute, In class exercise



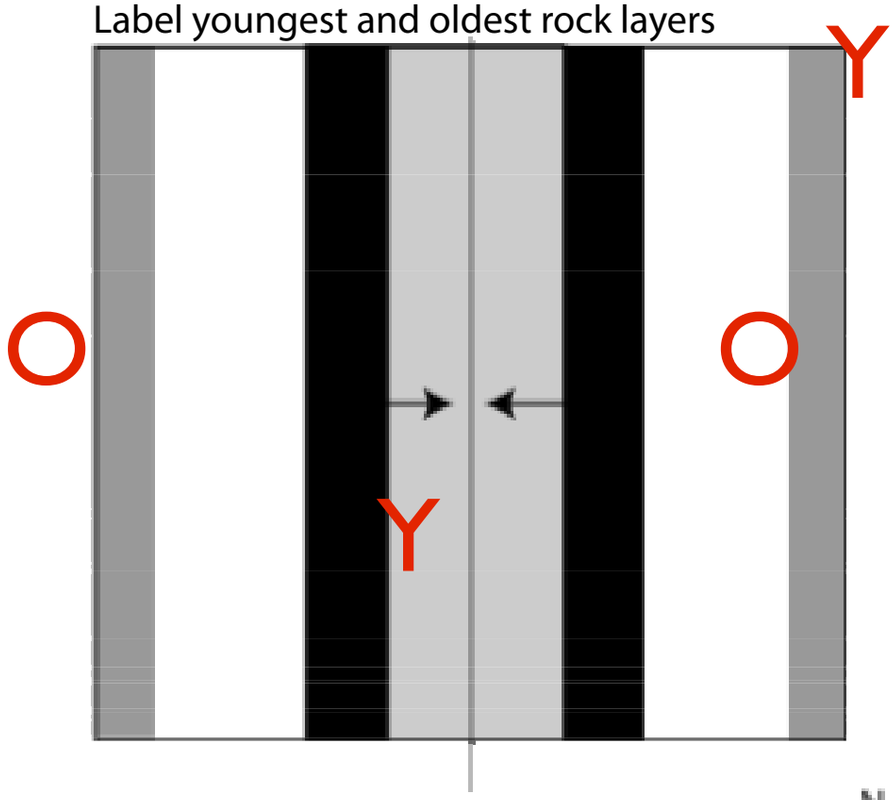
Locating an Earthquake:
10 to 15 minute, In class exercise



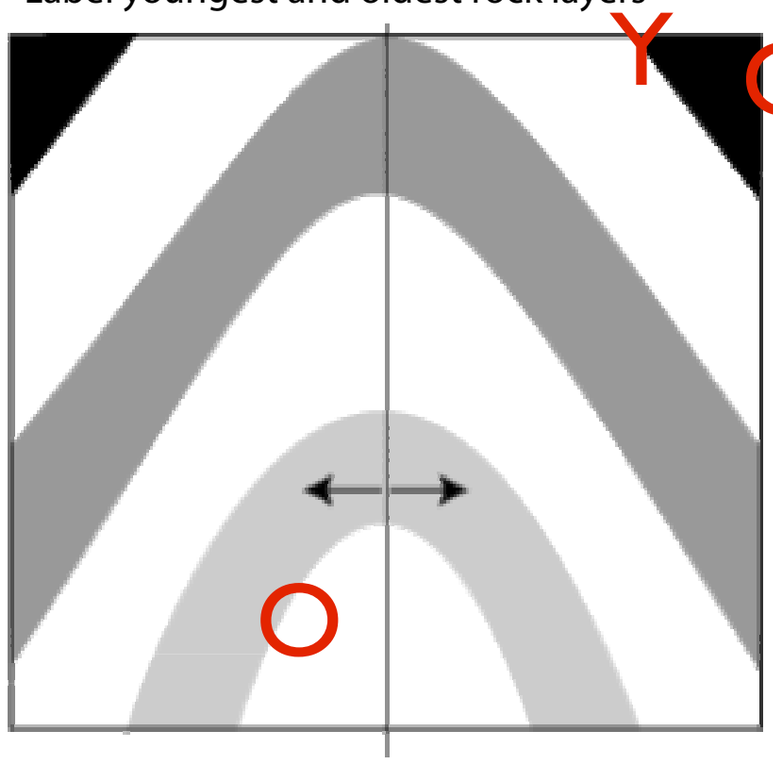
Locating an Earthquake:
10 to 15 minute, In class exercise



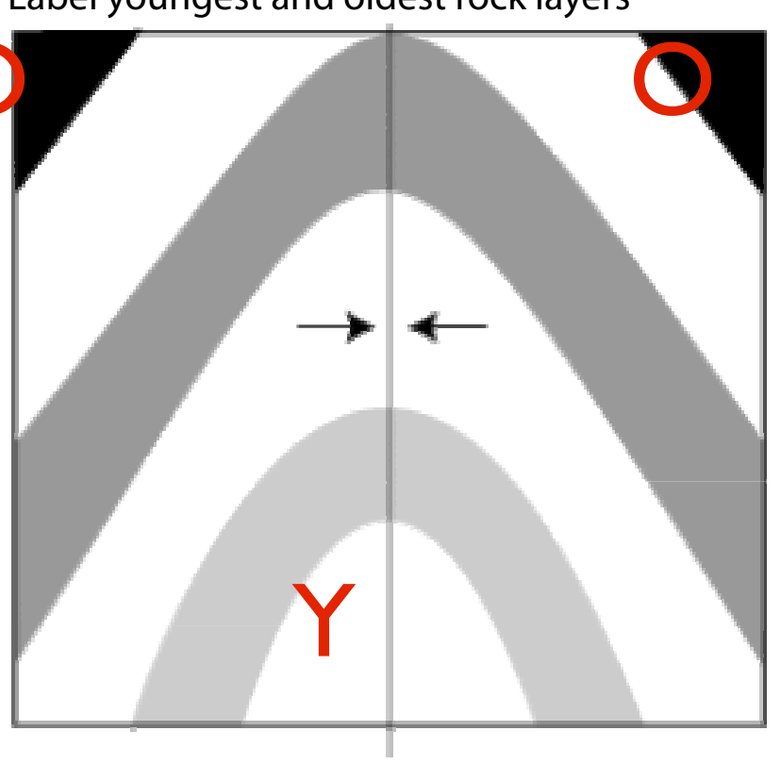
Syncline
Label youngest and oldest rock layers

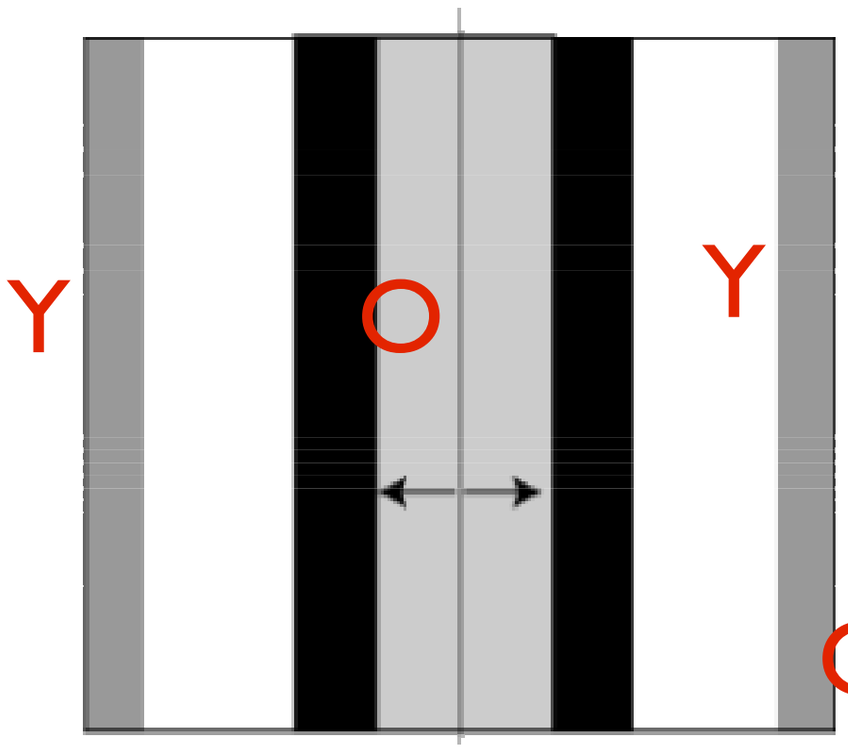


Plunging antiline
Label youngest and oldest rock layers

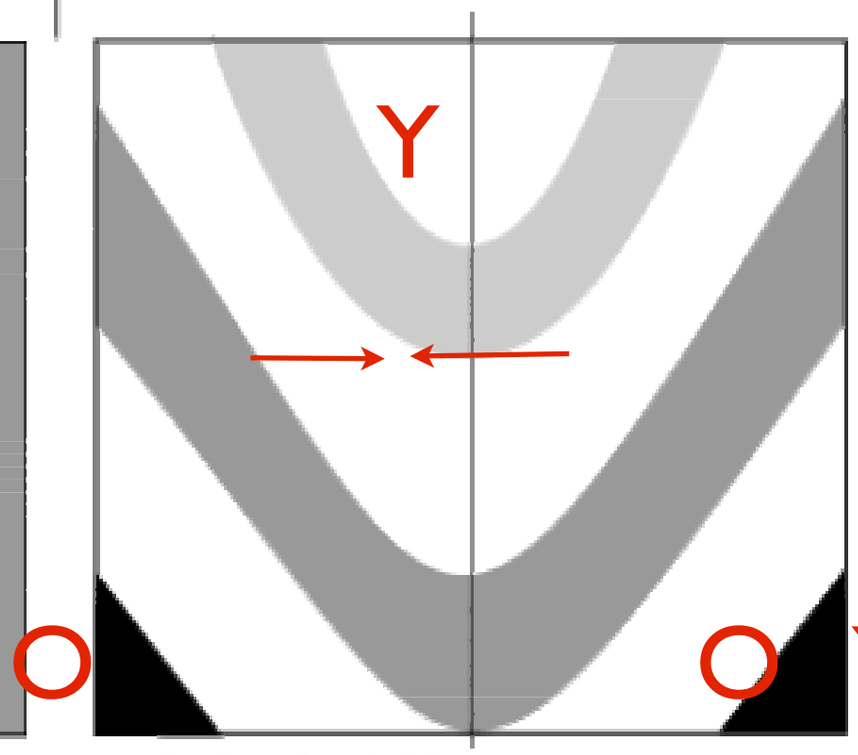


Plunging syncline
Label youngest and oldest rock layers

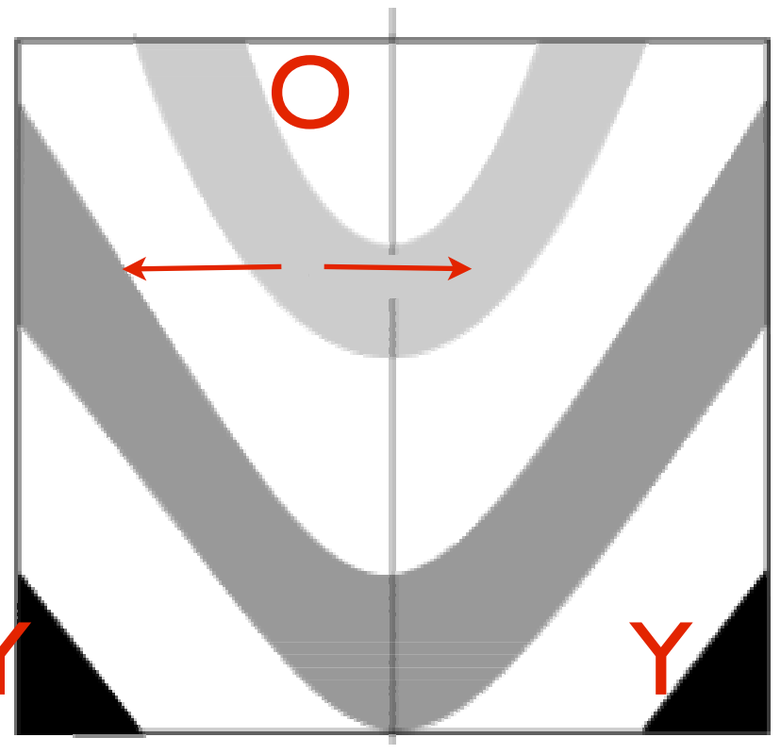




Anticline
Label youngest and oldest rock layers



North Plunging fold
Determine what type of fold this is, Label the fold axis and the youngest and oldes strata



South Plunging fold
Determine what type of fold this is, Label the fold axis and the youngest and oldes strata