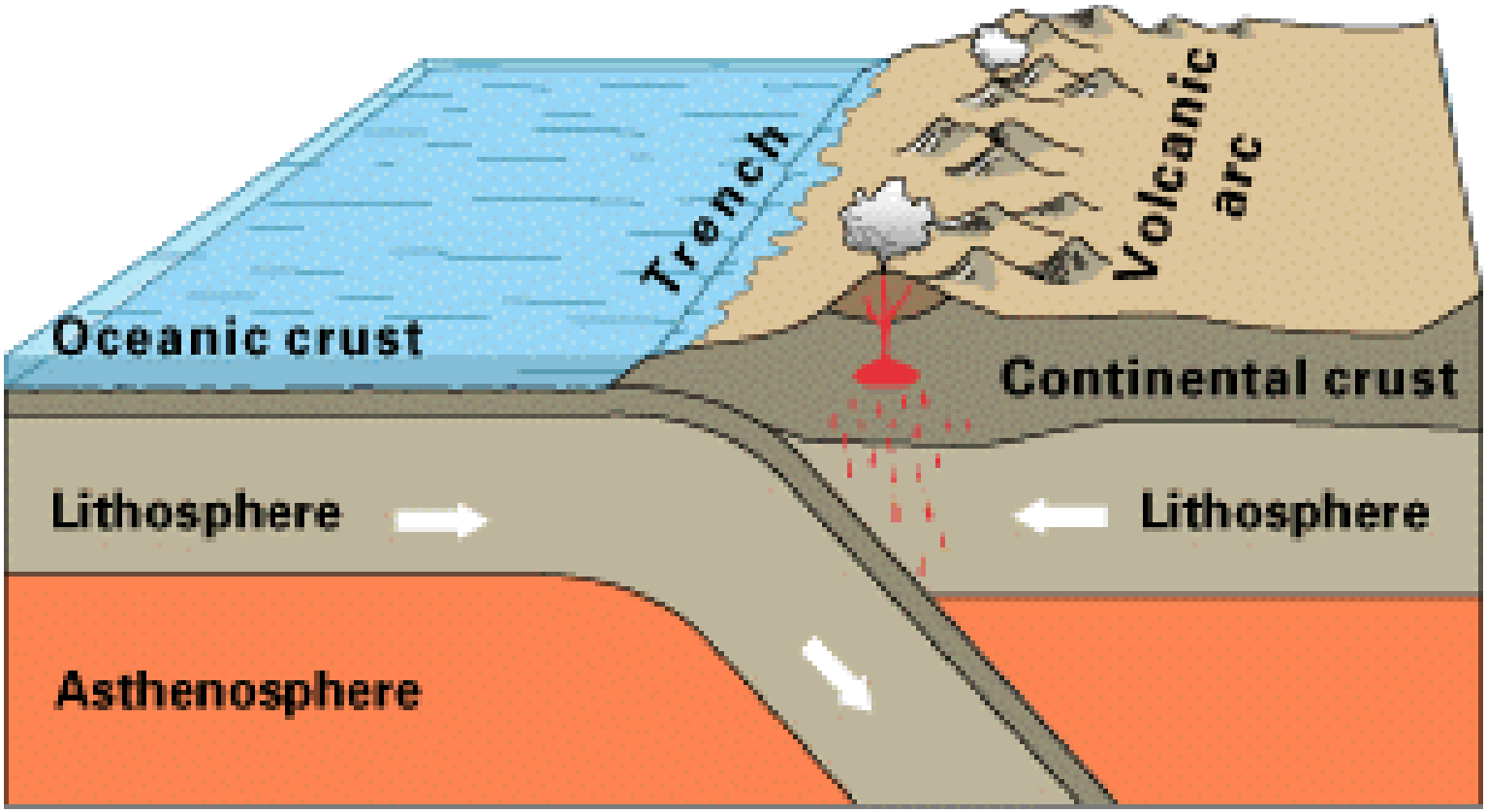
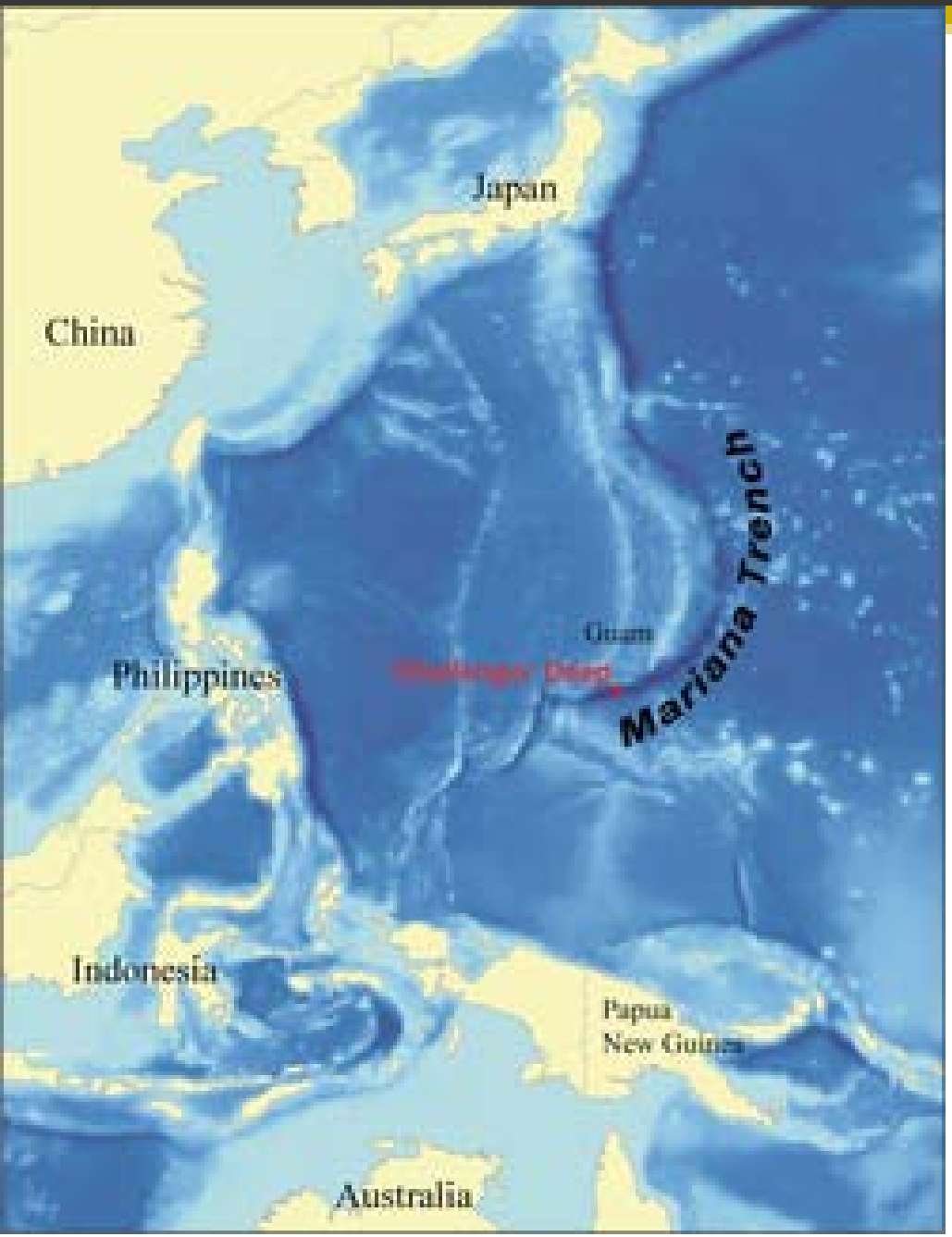
AP Environmental Science

Earth Systems Part 4

Plate Boundaries

- Convergent Boundaries
  - Ocean-Ocean –
    - one plate(typically the older one) will subduct under the other→ volcanic island arc
  - Ocean-Continental
    - The oceanic plate will subduct under the continental plate→ melt→ volcanic arc & trench
  - Continental-Continental
    - Neither plate will subduct→ plates begin to fold and crumble → mountain ranges


Trench
Volcanic arc
Oceanic crust
Continental crust
Lithosphere
Lithosphere
Asthenosphere



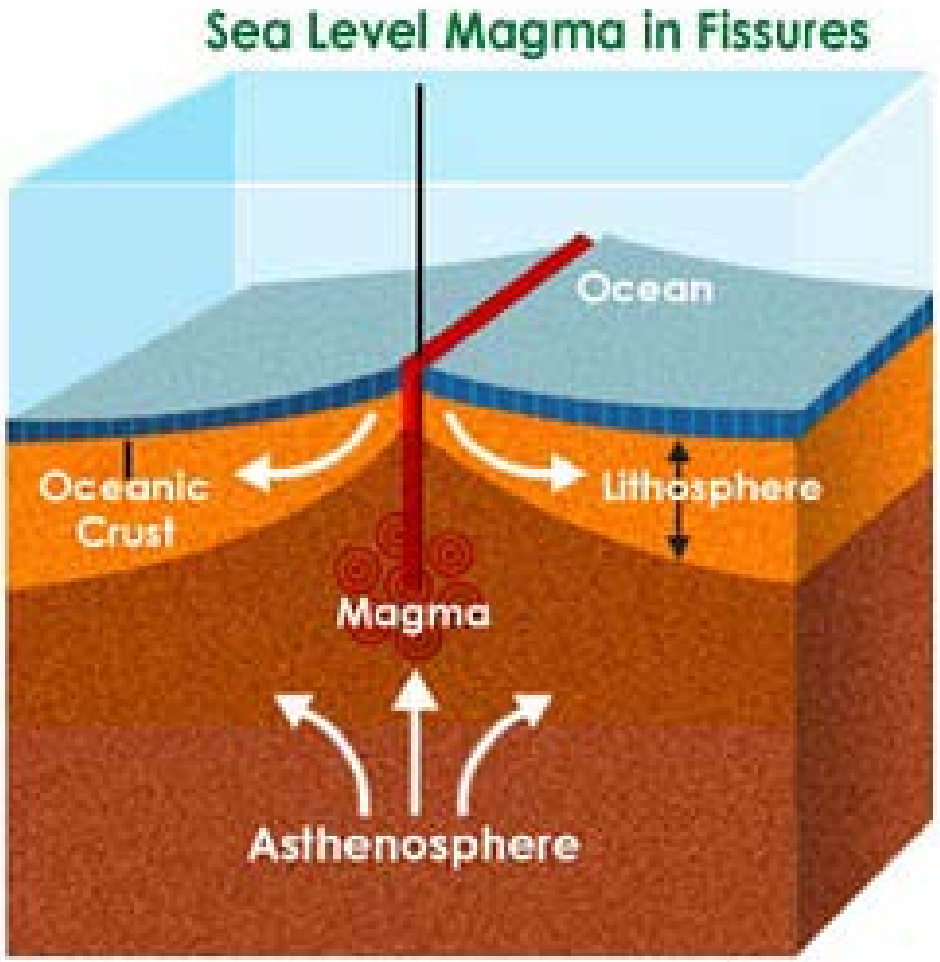
Mariana Trench – deepest part of the world's oceans

2550 km long, 70 km wide

Challenger Deep
11,033 meters deep (36,000 ft)

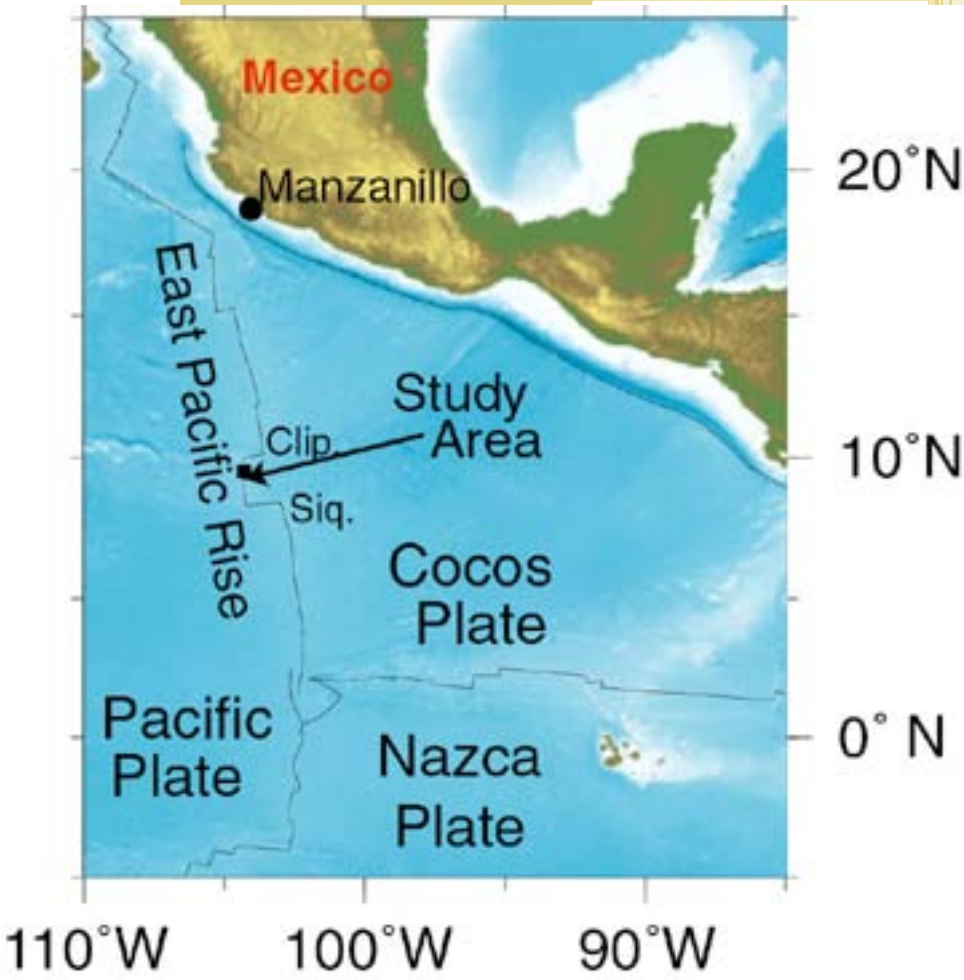
If Mt. Everest was set in the bottom it would be covered by 6000 ft of water

- Divergent Boundaries
  - Continental-Continental
    - Creates rift valleys
  - Ocean-Continental
    - Rift valleys and seas
  - Ocean-Ocean
    - Creates Mid-ocean ridges or rises



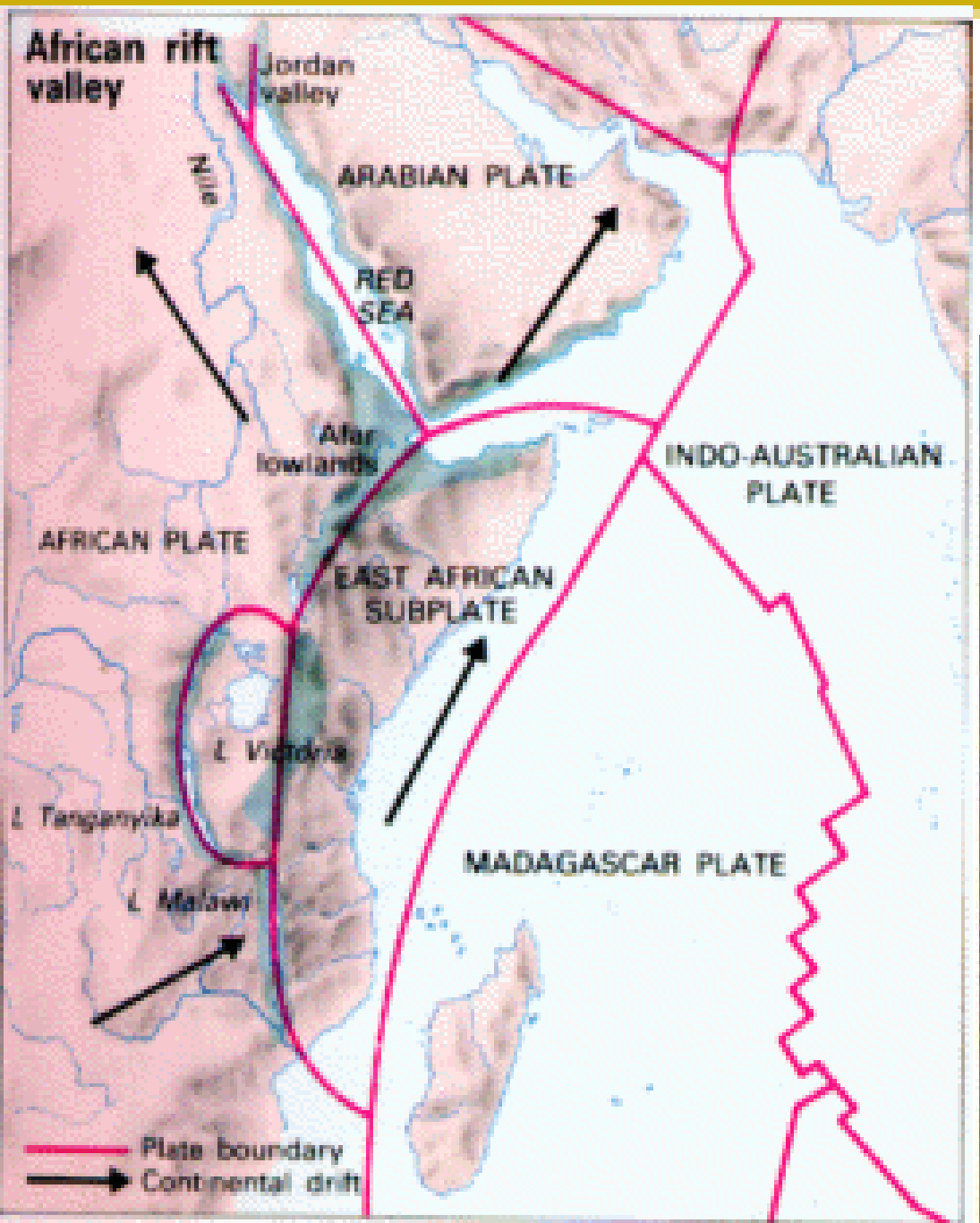
Divergent Boundaries

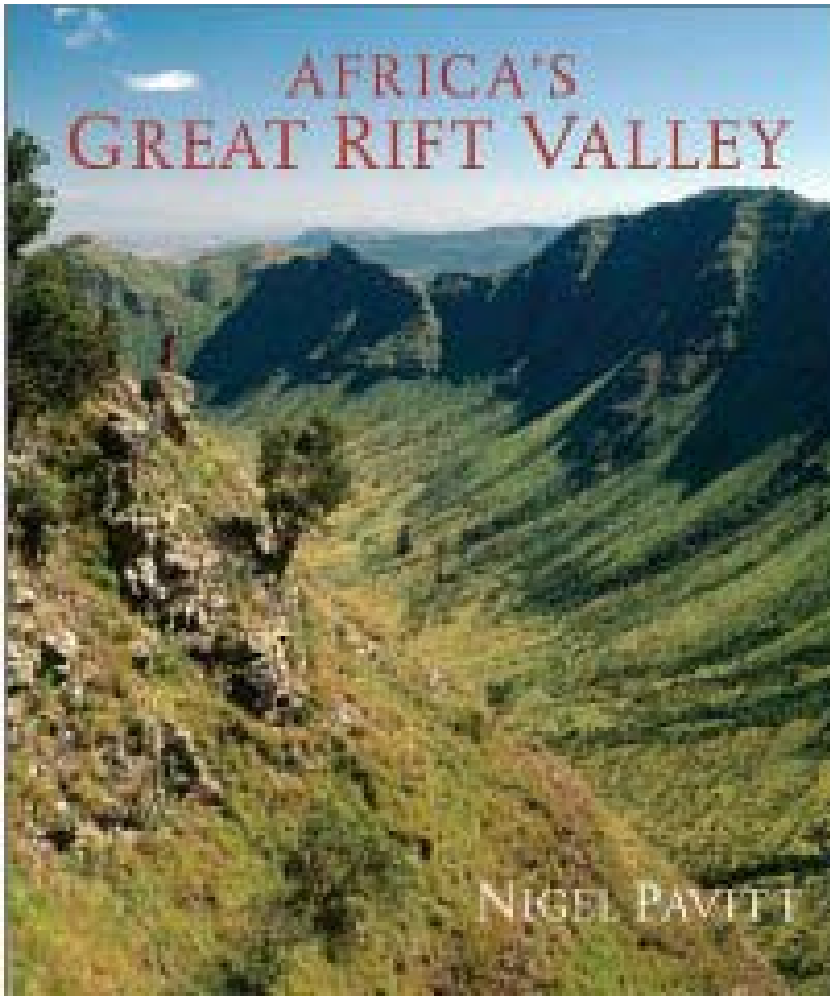
Mid-Atlantic Ridge



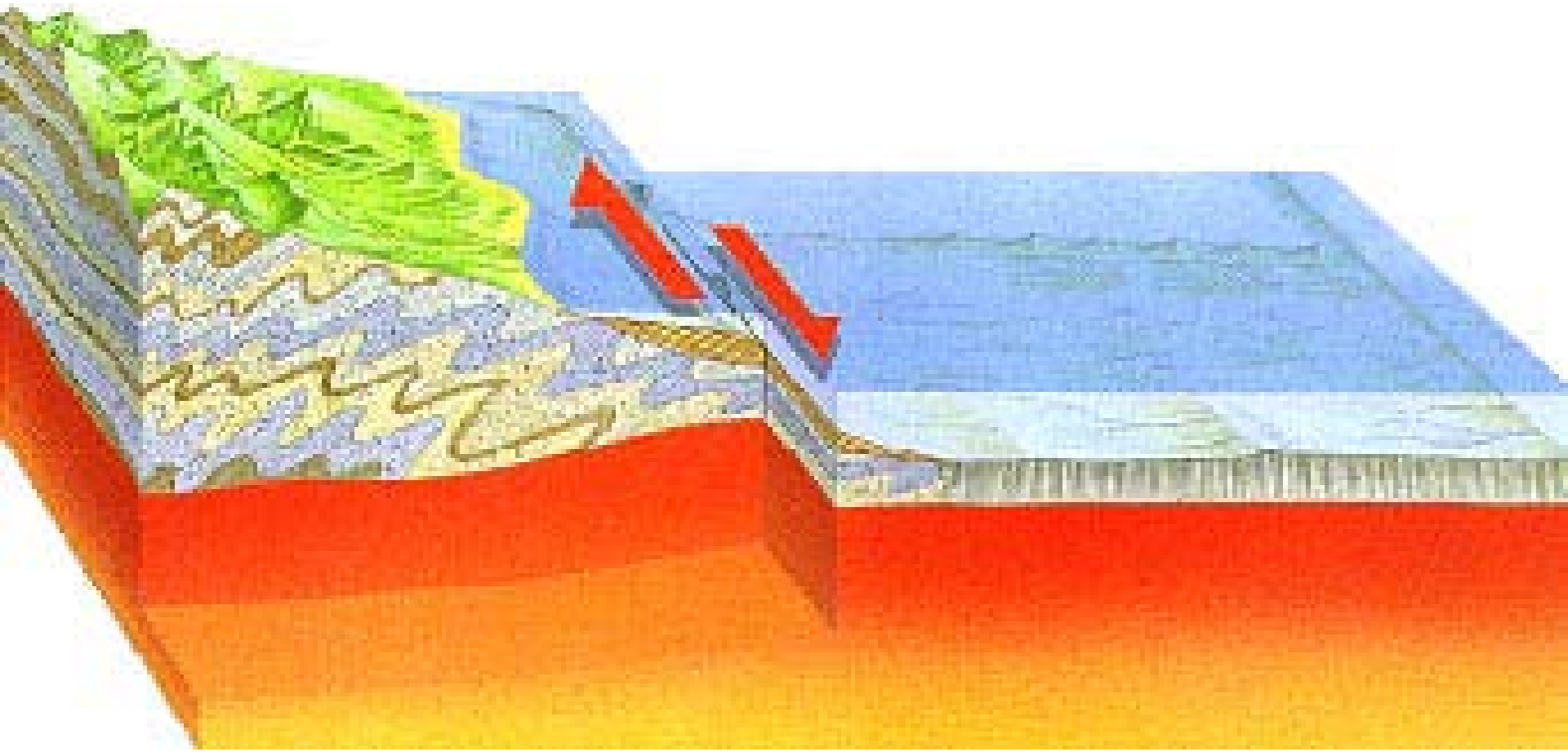
East Pacific Rise

Map of the Red Sea


African rift valley
Jordan valley
Nile
ARABIAN PLATE
RED SEA
Afar lowlands
INDO-AUSTRALIAN PLATE
AFRICAN PLATE
EAST AFRICAN SUBPLATE
L. Victoria
L. Tanganyika
L. Malawi
MADAGASCAR PLATE
Plate boundary
Continental drift


AFRICA'S
GREAT RIFT VALLEY
NIGEL PAVITT

- Transform Boundary
  - Strike-slip
    - Smaller rift valleys

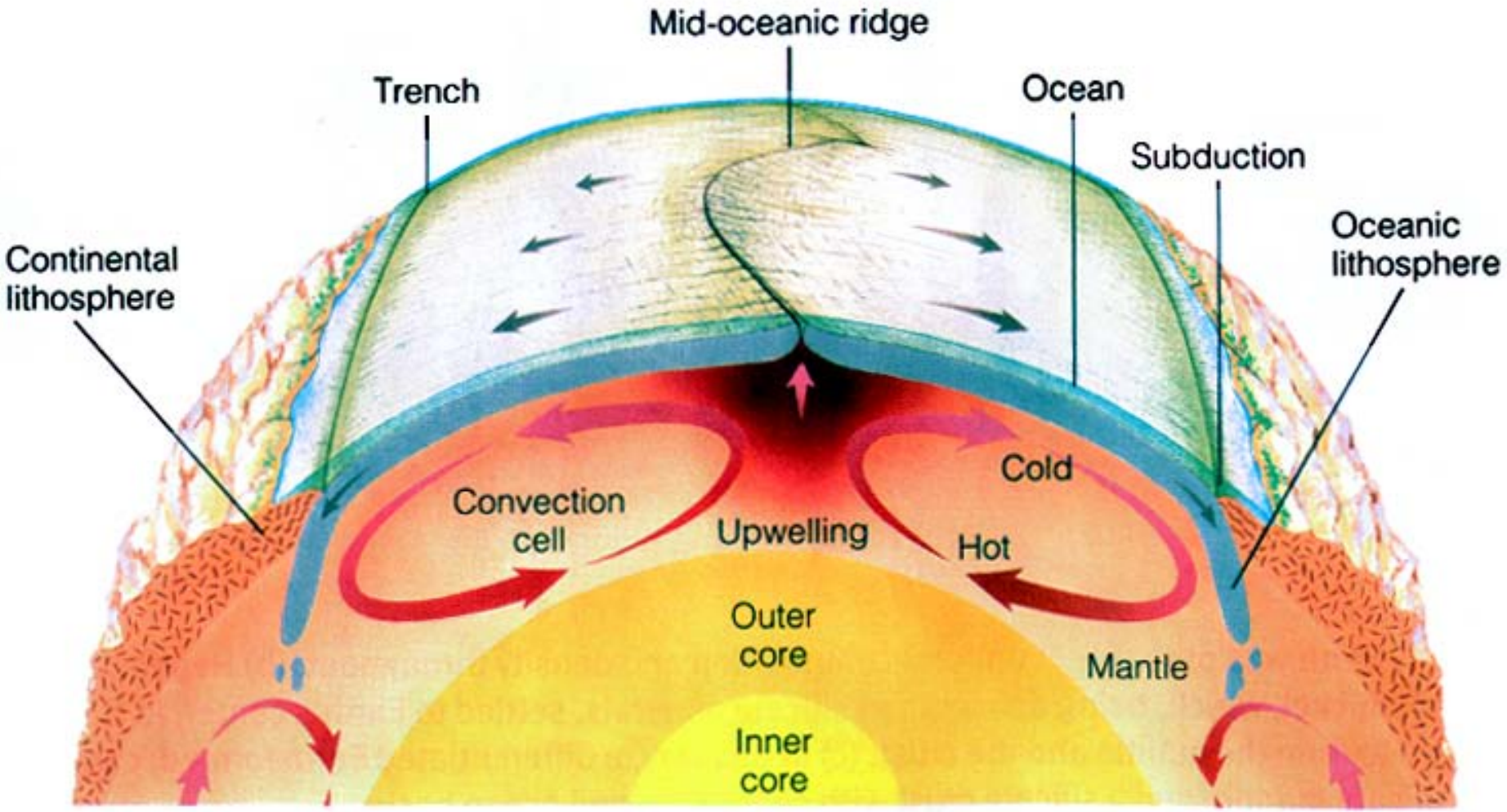


The San Andreas Fault

Extends roughly 1300 km (800 miles)

- The interaction of the plates at the different boundaries is what creates mountains, causes volcanoes and earthquakes, and oceanic trenches
- It also helps explain the patterns of biological evolution
- The tectonic plates typically move at a rate of 5-10 cm/ year
- The plates are able to move cause they have a lower density and are stronger in composition than the mantle below

- The motion of the plates is driven by heat from two sources
  - Radioactive decay of elements deep in the earth
  - Residual heat left over from the genesis of the Earth
- Heat drives convection currents, warm magma rises toward the surface, as it reaches the surface it cools and sinks, and repeat



Convection Cells of the Mantle

Mechanism for Movement

- Interacting forces fueled by the convection cells in the Earth's mantle move the plates around the globe
  - Ridge Push
    - As magma forces it way between plates at the divergent boundaries, it cools and hardens pushing the plates further apart
  - Slab Pull
    - Once a plate has subducted under another one, the weight of the plate actually pulls the rest of the plate down with it

Volcanoes

- An opening or rupture in the Earth's crust
- Named after the Roman god of fire- Vulcan
- Typically found at divergent and convergent boundaries
- Mid Ocean ridges are continuous chains of volcanoes caused by divergent boundaries
- The **Pacific Ring of Fire** is so named to describe the ring of volcanoes created by convergent boundaries of the Pacific plate

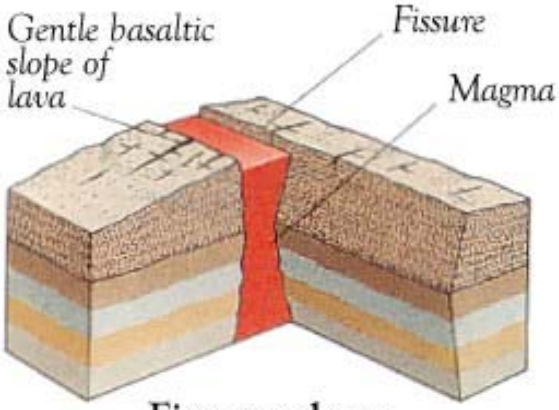
- Some Volcanoes are also caused by Hotspots, random mantle plumes that penetrate the crust and erupt, usually forming island like Hawaii
- Volcano Types
  - Fissure Vents
    - Cracks the emit lava
  - Shield Volcanoes
    - Broad shield like profiles, formed from low viscosity lava, no explosions
  - Cinder Cone Volcanoes
    - Eruption of pyroclastic material (cinder)

- Lava Domes
  - Slow eruptions of high viscosity lava
- Composite Volcanoes
  - Alternating layers of ejecta and lava flows

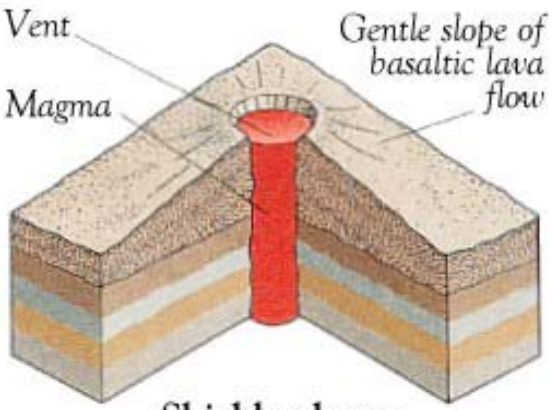
Lava Types

- Felsic – high percentage of silica, high viscosity, tend to trap gases and cause catastrophic eruptions
- Mafic/Basaltic –contains high percentages of Magnesium and Iron, lower viscosity, tend to be hotter, tend to create oceanic plates

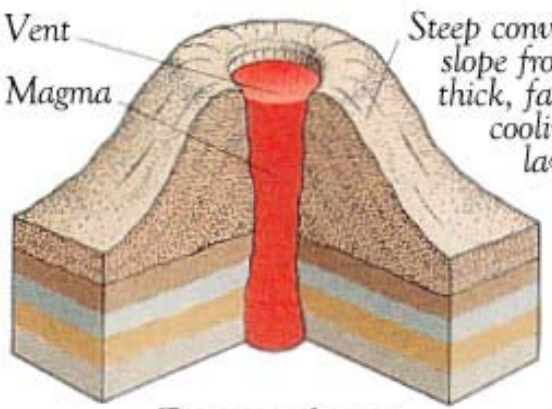
TYPES OF VOLCANO



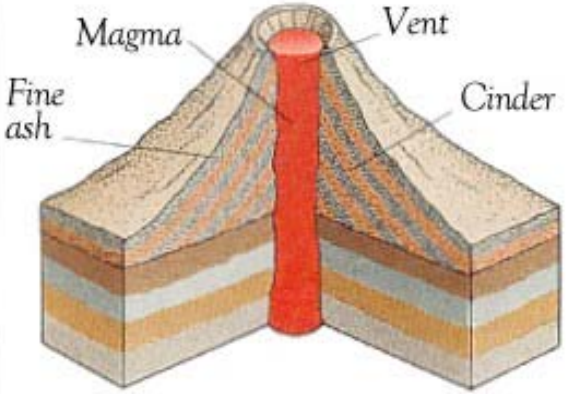
Fissure volcano



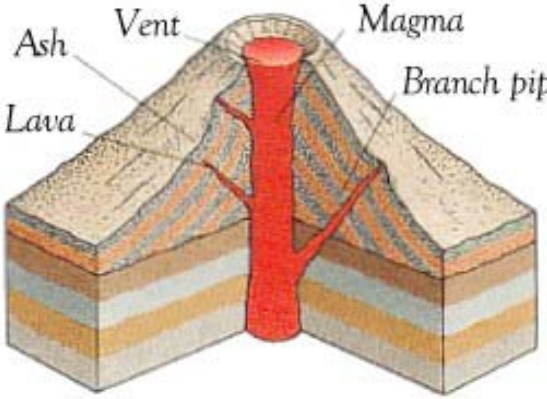
Shield volcano



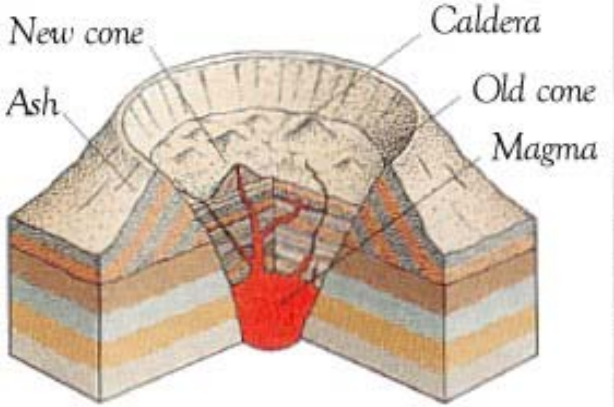
Dome volcano



Ash-cinder volcano



Composite volcano



Caldera volcano

Shield Volcano

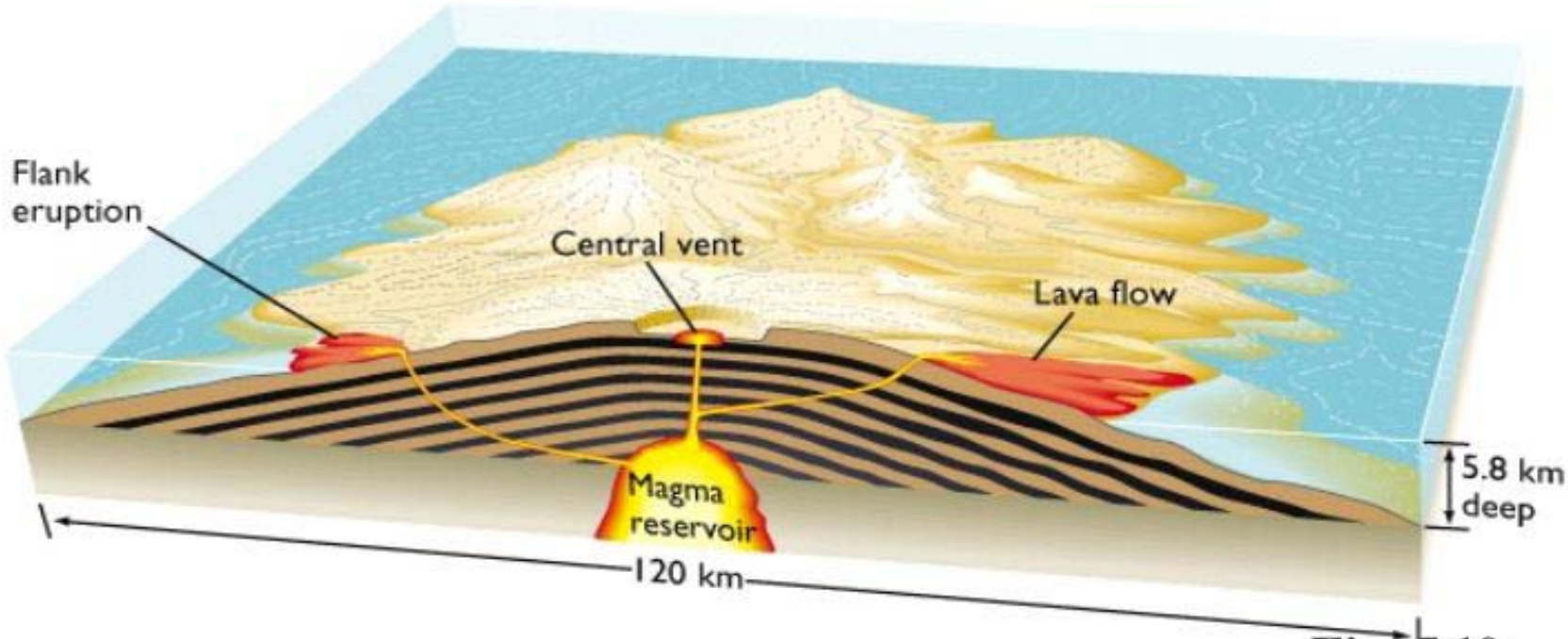


Fig. 5.10

Mt. Fugi in Japan, Conical Cinder Cone Volcano

Lakagiger Fissure Vent in Iceland

Chaiten Volcano in southern Chile during the 2008-2009 eruption

Mt. Mayon-, Philippines, stratovolcano

Mt. Piatubo ash plume, reaching 19km a few days before it 1991 eruption

Mt. Cleveland in the Alutiian Islands Alaska photo from the International Space Station, May 2006

Mauna Loa Hawaii, Shield Volcano, largest volcano on earth in terms of area and volume. 4170 m (13860 ft)above sea level, 28,680 ft from sea floor

French Volcanologists, Maurice and Katia Krafft where killed in a 1991 eruption of Mount Unzen, Japan. They along with 40 journalists were killed in an unexpected pyroclastic flow

Eruption of Mount Unzen Showing Pyroclastic Flow, Japan, 1991

Victims in Pompeii, a nearby Roman village encapsulated by a pryoclastic flow during the eruption of Mt. Vesuvius in 79AD

NATIONAL GEOGRAPHIC

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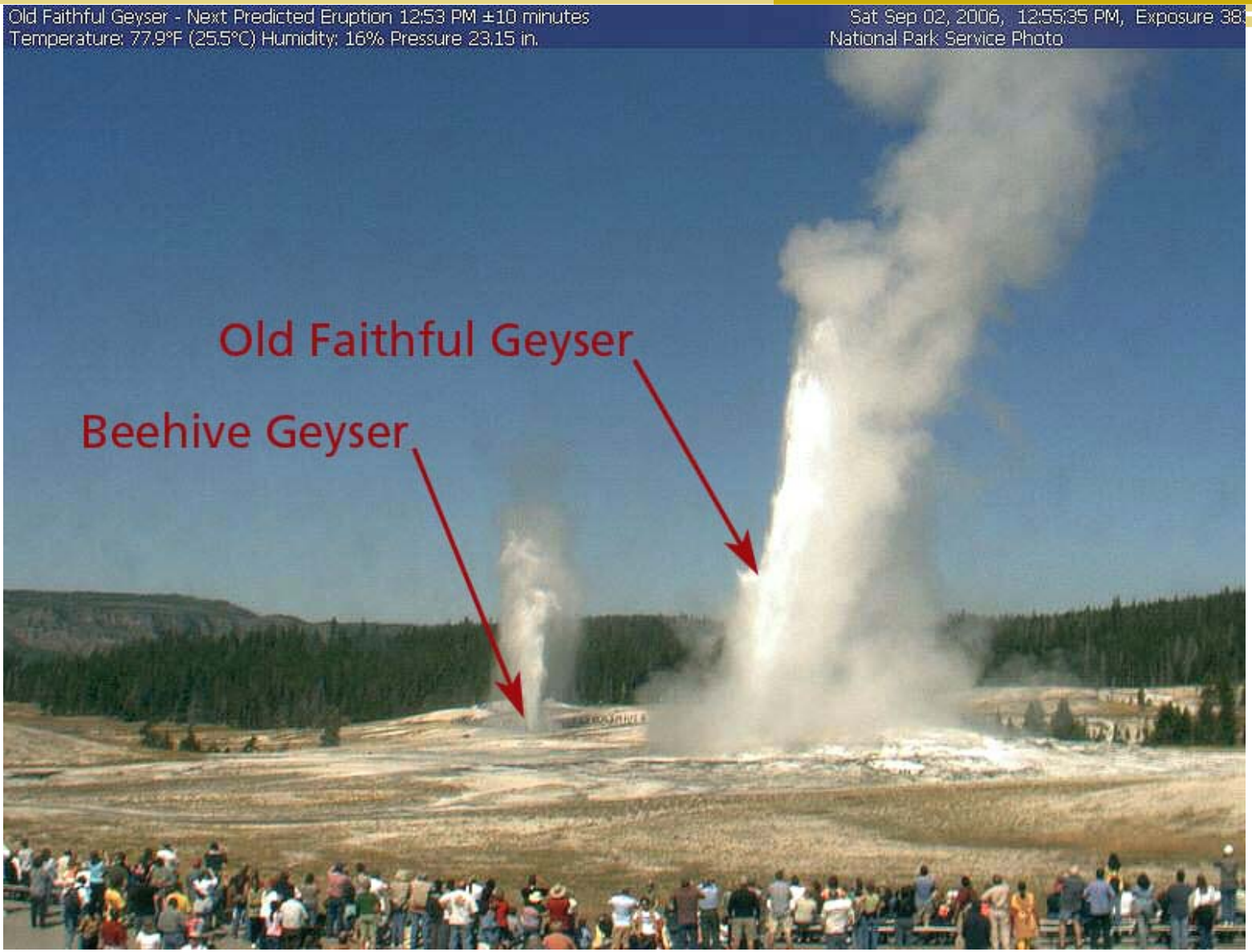
Gardiner
Silver Gate
MONTANA
WYOMING
Mammoth Hot Springs
Tower Junction
MONTANA
WYOMING
Magnitude 7.5
August 18, 1959
YELLOWSTONE
NATIONAL PARK
West Yellowstone
Norris
Madison
Canyon
CALDERA RIM
Magnitude 6.1
June 30, 1975
Fishing Bridge
Old Faithful
Yellowstone
Lake
Lake Butte
West Thumb
IDAHO
WYOMING
CALDERA RIM
10 MILES
USGS
Topinka, USGS, 1997, Modified from: Dzurisin, Chrisitensen, and Pierce, 1995


Old Faithful Geyser - Next Predicted Eruption 12:53 PM ±10 minutes
Temperature: 77.9°F (25.5°C) Humidity: 16% Pressure 23.15 in.
Sat Sep 02, 2006, 12:55:35 PM, Exposure 38
National Park Service Photo
Old Faithful Geyser
Beehive Geyser

Extent of ash deposits from Yellowstone's giant eruption 630,000 years ago

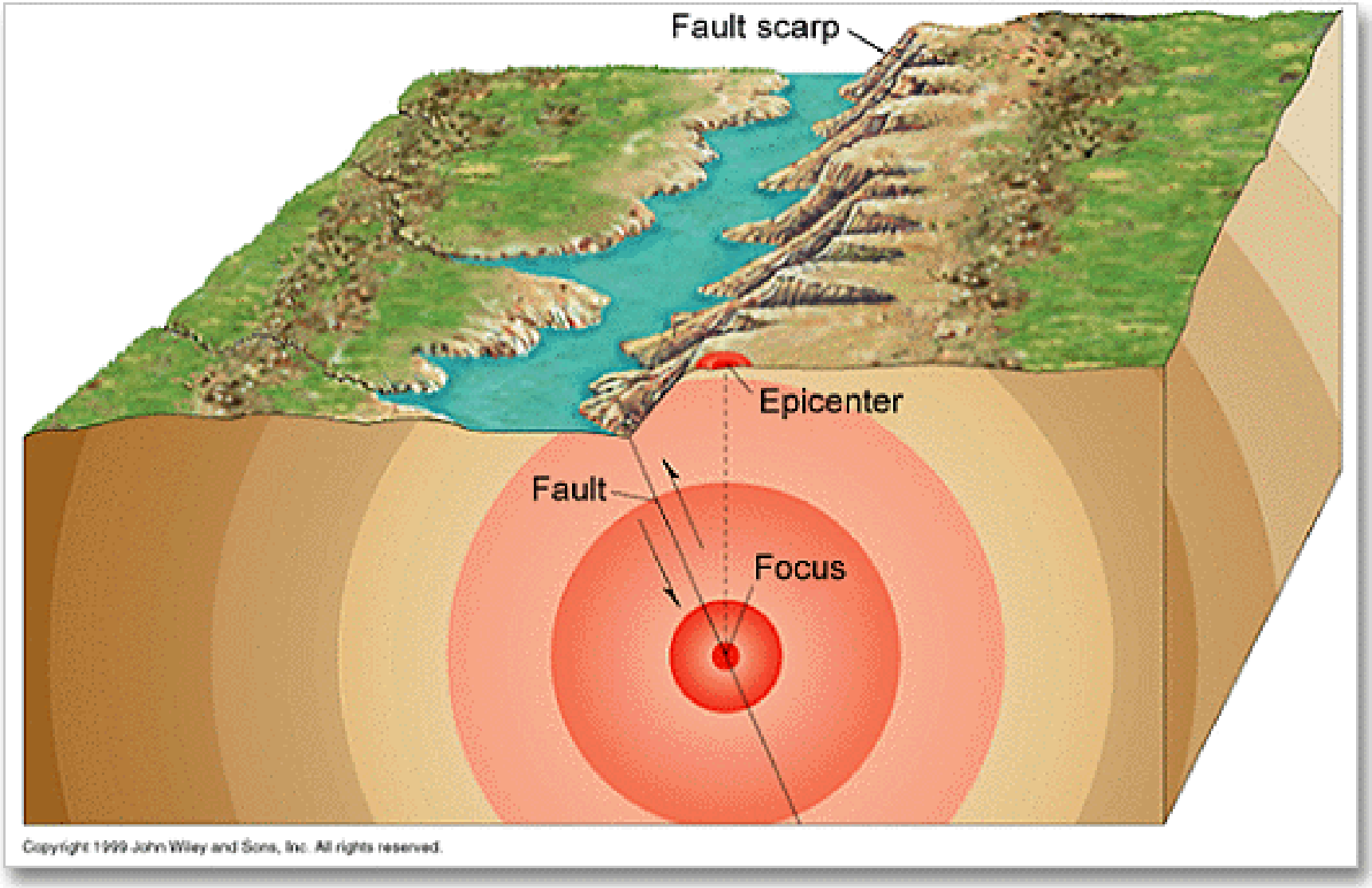
Mt St. Helens before the 1980 eruption

Mt. St. Helens after the 1980 eruption

Short Eruption Video

Earthquakes

- **Earthquake**-the result of a sudden release of energy from the Earth's crust that creates seismic waves.
- Recorded with seismometer / seismograph
- Measured on the Richter scale or the modified Mercalli scale
- Tension is built up from the movement and collisions of the tectonic plates under the surface.
- **Focus**- underground center, **epicenter**- above focus



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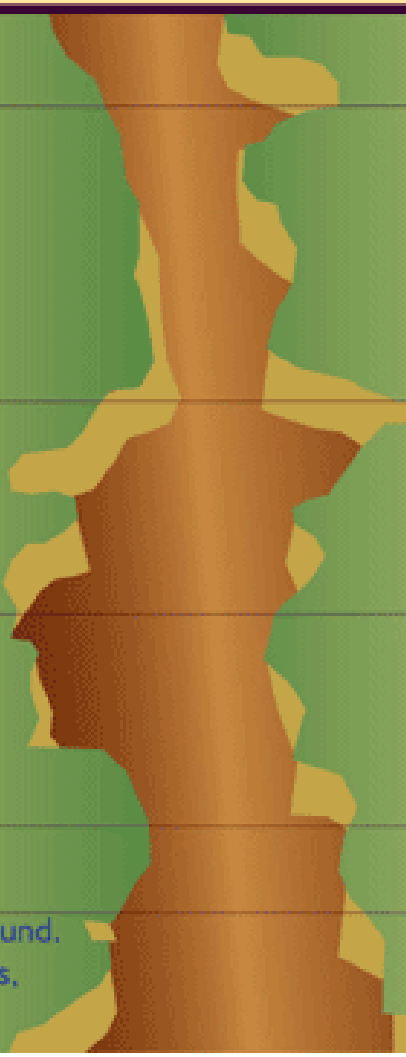
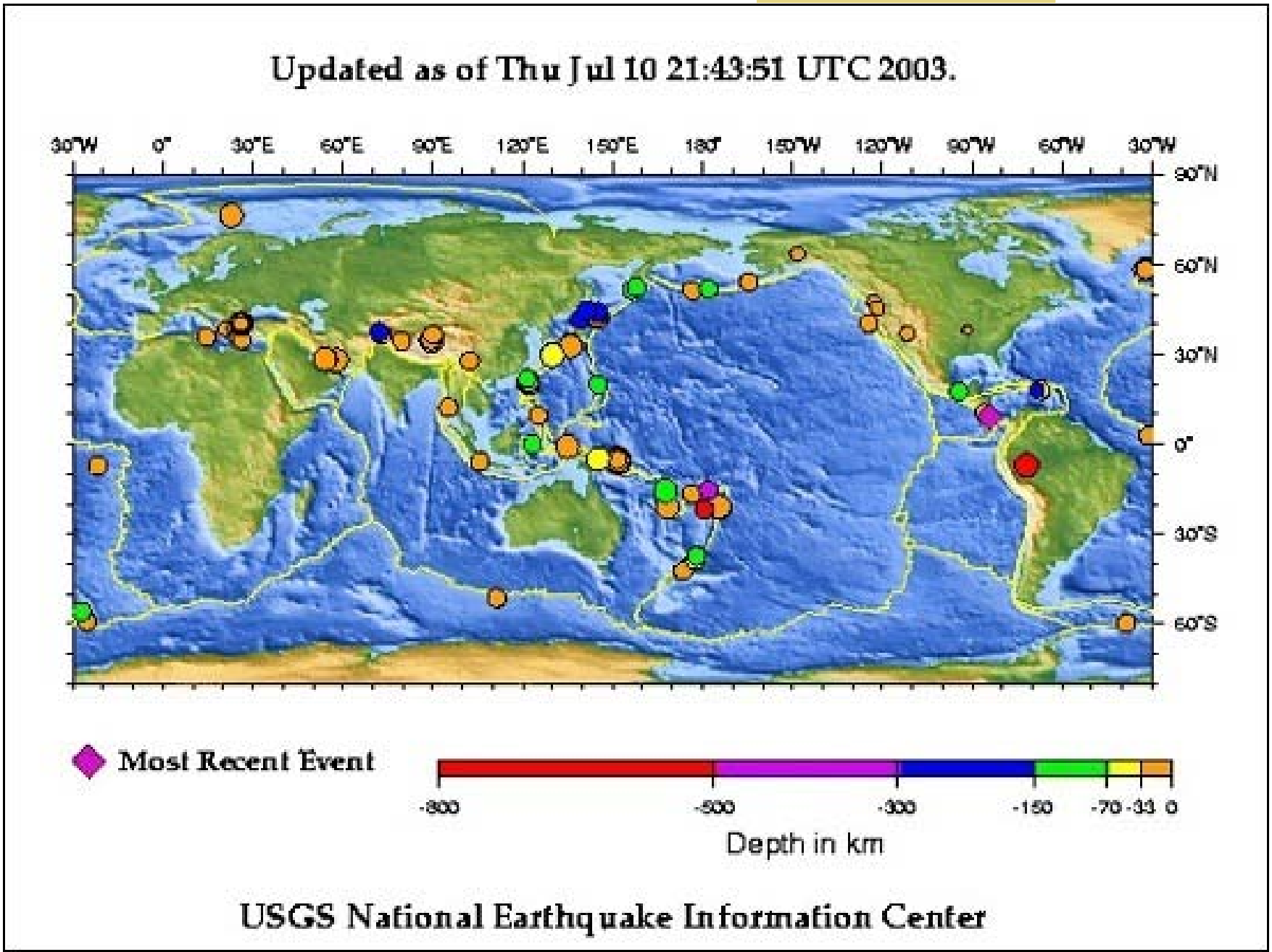
RICHTER SCALE of earthquake energy:

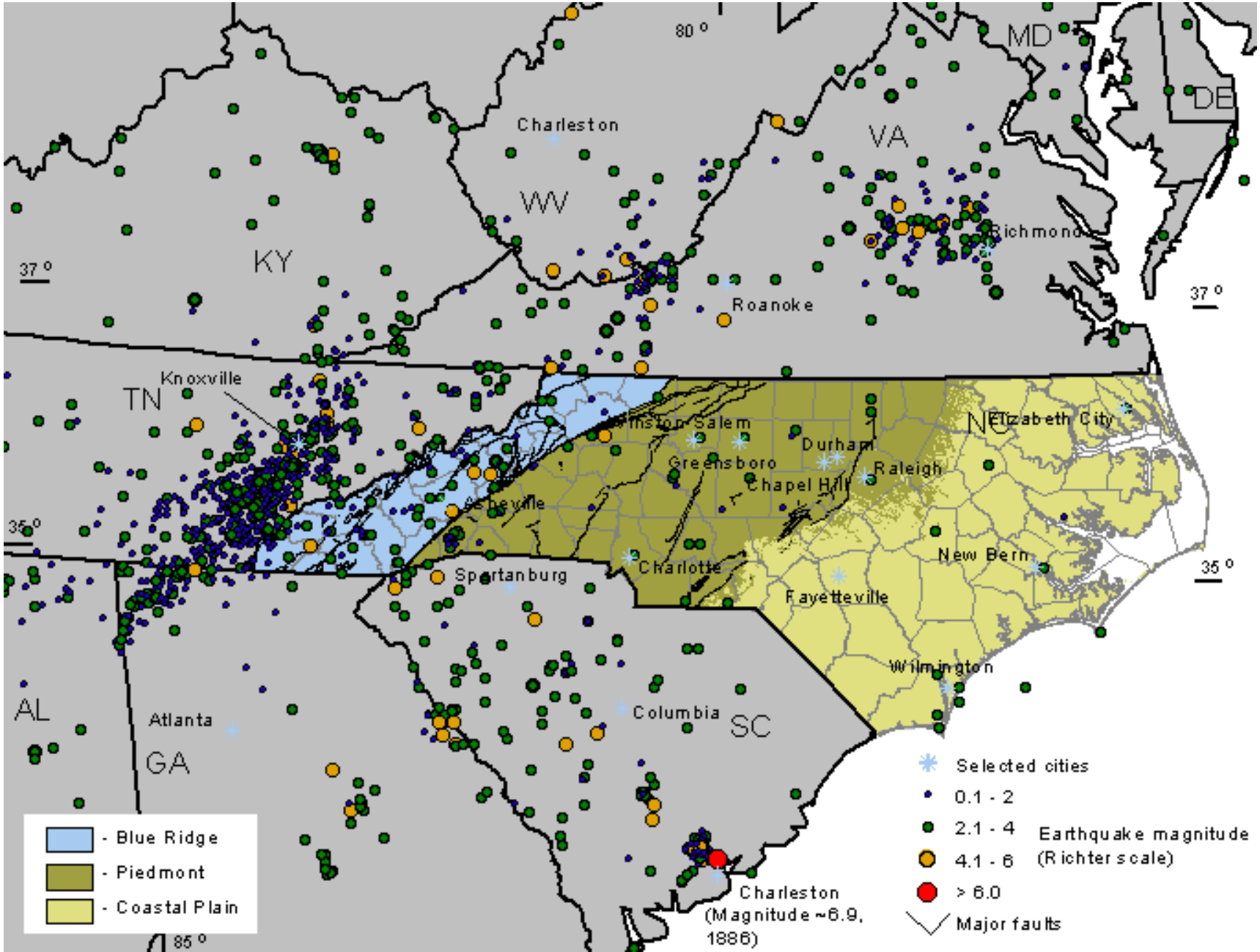
Each level is **10 times stronger** than the previous level

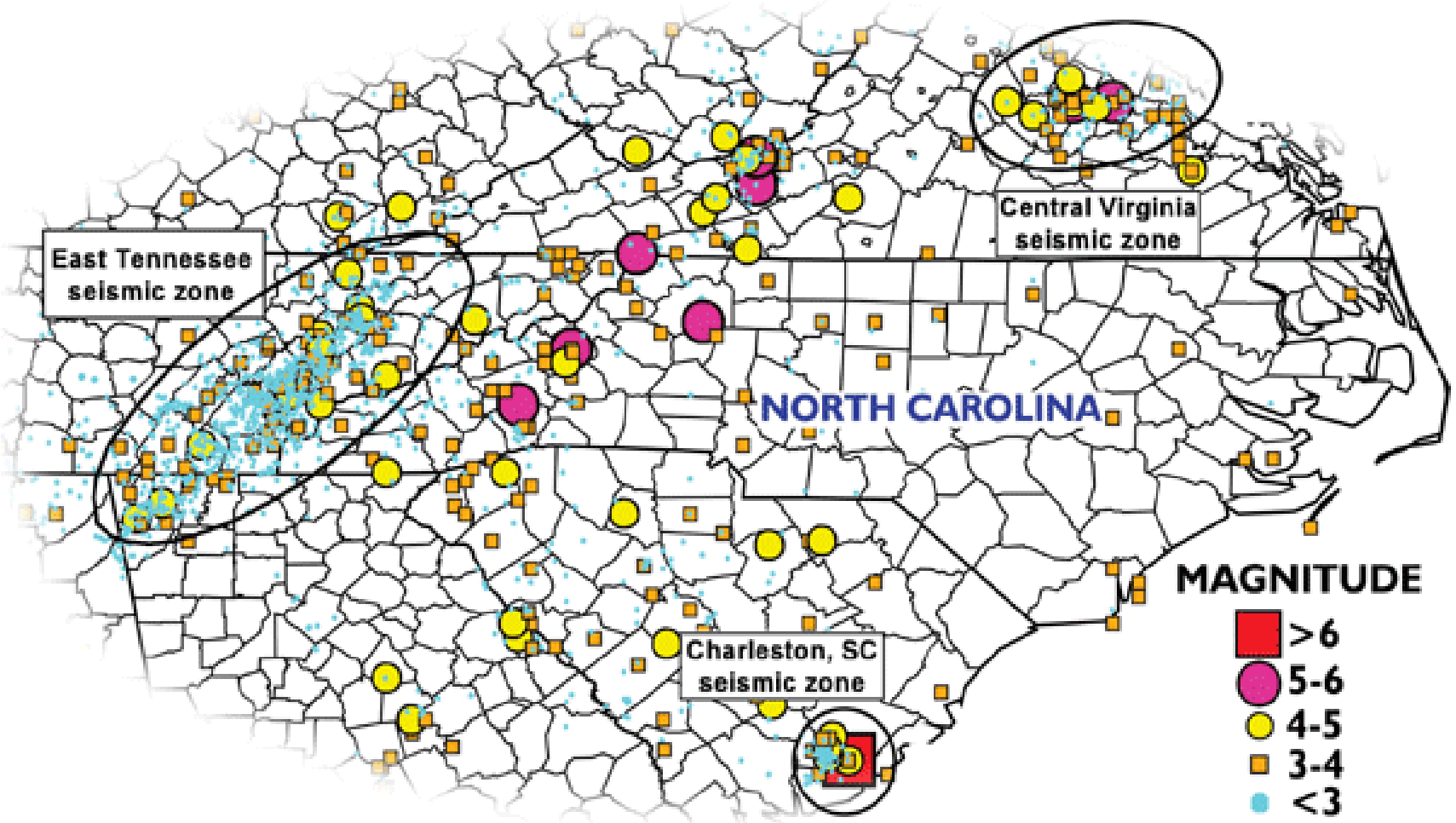
	Description	Occurrence	In Population	Movement
1	SMALL	DAILY	every minute	small
2	SMALL	DAILY	every hour	small
3	SMALL	DAILY	every day	small
4	SMALL	DAILY	every week	moderate sudden
5	MODERATE	MONTHLY	every 10 years	strong sudden
6	MODERATE	MONTHLY	every 30 years	strong sudden
7	MAJOR	MONTHLY	every 50 years.	severe sudden
8	GREAT	YEARLY	every 100 years	very severe
9	GREAT	YEARLY	every 300 years	very severe
10	SUPER	RARELY	every 1000 years	extreme

MODIFIED MERCALLI SCALE		RICHTER SCALE	
I.	Felt by almost no one.	2.5	Generally not felt, but recorded on seismometers.
II.	Felt by very few people.		
III.	Tremor noticed by many, but they often do not realize it is an earthquake.	3.5	Felt by many people.
IV.	Felt indoors by many. Feels like a truck has struck the building.		
V.	Felt by nearly everyone; many people awakened. Swaying trees and poles may be observed.		
VI.	Felt by all; many people run outdoors. Furniture moved, slight damage occurs.	4.5	Some local damage may occur.
VII.	Everyone runs outdoors. Poorly built structures considerably damaged; slight damage elsewhere.		
VIII.	Specially designed structures damaged slightly, others collapse.	6.0	A destructive earthquake.
IX.	All buildings considerably damaged, many shift off foundations, Noticeable cracks in ground.		
X.	Many structures destroyed. Ground is badly cracked.	7.0	A major earthquake.
XI.	Almost all structures fall. Very wide cracks in ground.	8.0 and up	Great earthquakes.
XII.	Total destruction. Waves seen on ground surfaces, objects are tumbled and tossed.		



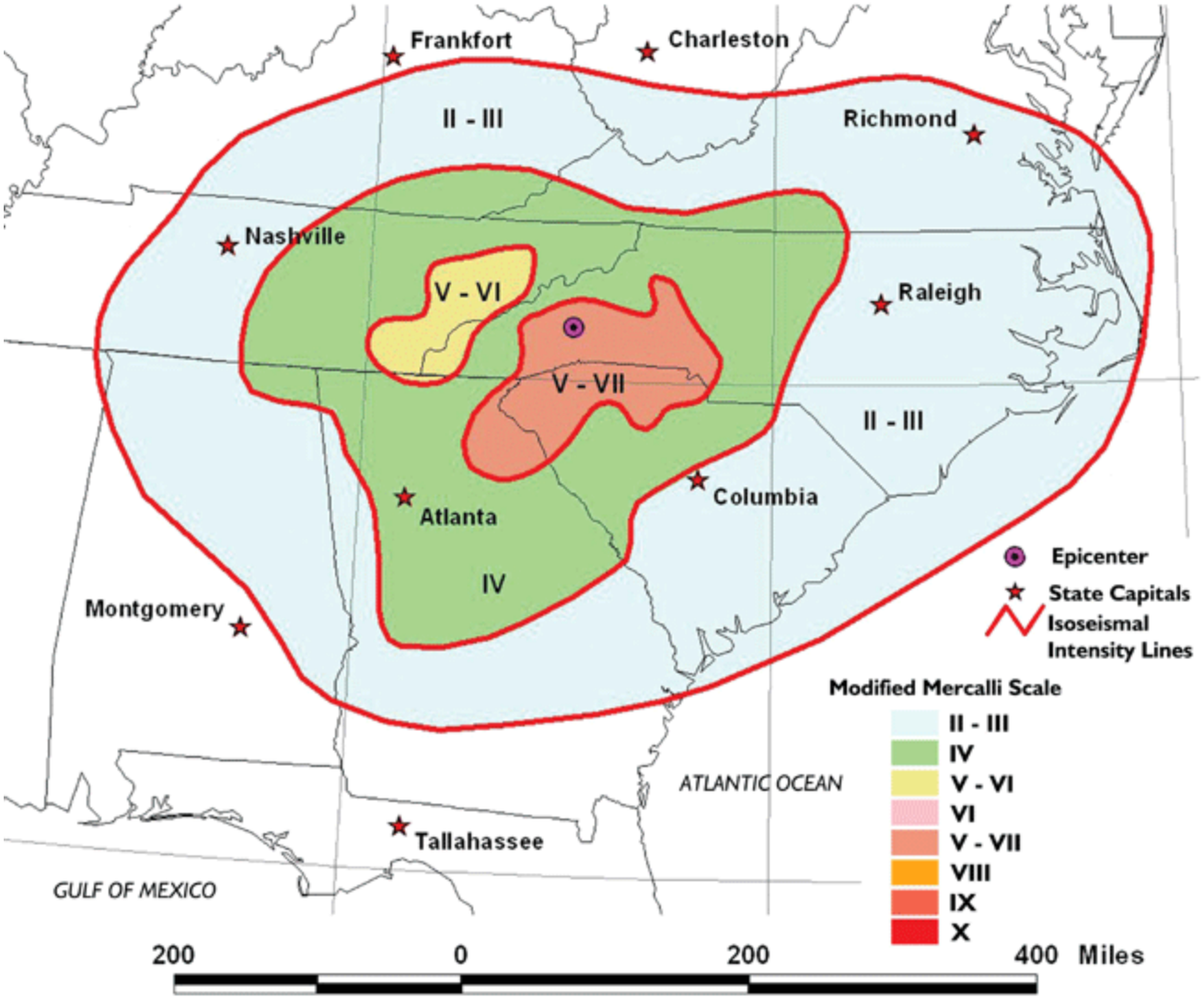

Updated as of Thu Jul 10 21:43:51 UTC 2003.
30°W
0°
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
90°N
60°N
30°N
0°
30°S
60°S
Most Recent Event
-600
-300
-150
-70
-33
0
Depth in km
USGS National Earthquake Information Center


80 °
MD
DE
Charleston
VA
WV
Richmond
37 °
KY
Roanoke
37 °
Knoxville
TN
Winston-Salem
Durham
Elizabeth City
NC
Greensboro
Raleigh
Chapel Hill
35 °
Asheville
New Bern
35 °
Charlotte
Spartanburg
Fayetteville
Wilmington
AL
Atlanta
Columbia
SC
GA
- Blue Ridge
- Piedmont
- Coastal Plain
85 °
Selected cities
0.1 - 2
2.1 - 4
4.1 - 6
> 6.0
Earthquake magnitude
(Richter scale)
Major faults
Charleston
(Magnitude ~6.9,
1886)


East Tennessee seismic zone
Central Virginia seismic zone
NORTH CAROLINA
Charleston, SC seismic zone
MAGNITUDE
>6
5-6
4-5
3-4
<3

North Carolina Most Damaging Earthquakes

Year	Epicenter	Magnitude	Mercalli Intensity
1861	Near Wilkesboro, Wilkes County	5.0	VI
1916	Near Skyland, Buncombe County	5.2	VII
1926	Southern Mitchell County	5-6	VII
1957	Near Woodlawn, McDowell County	4.0	VI
1957	Buncombe County	3.7	VI
1957	Northwest Jackson County	3.9	VI
1981	Near Hendersonville, Henderson County	3.5	VI

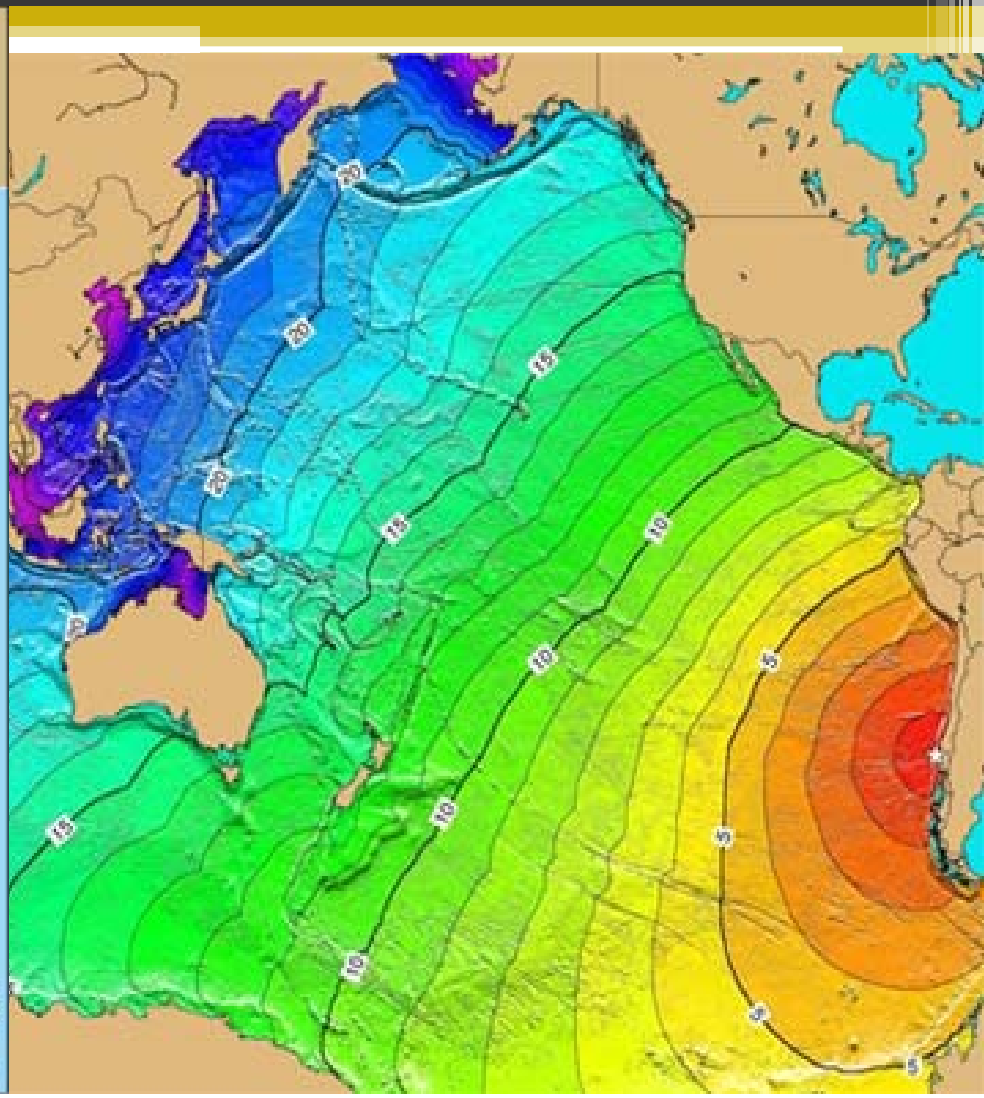


An isoseismic map showing how widespread the 1916 Buncombe County Quake was felt

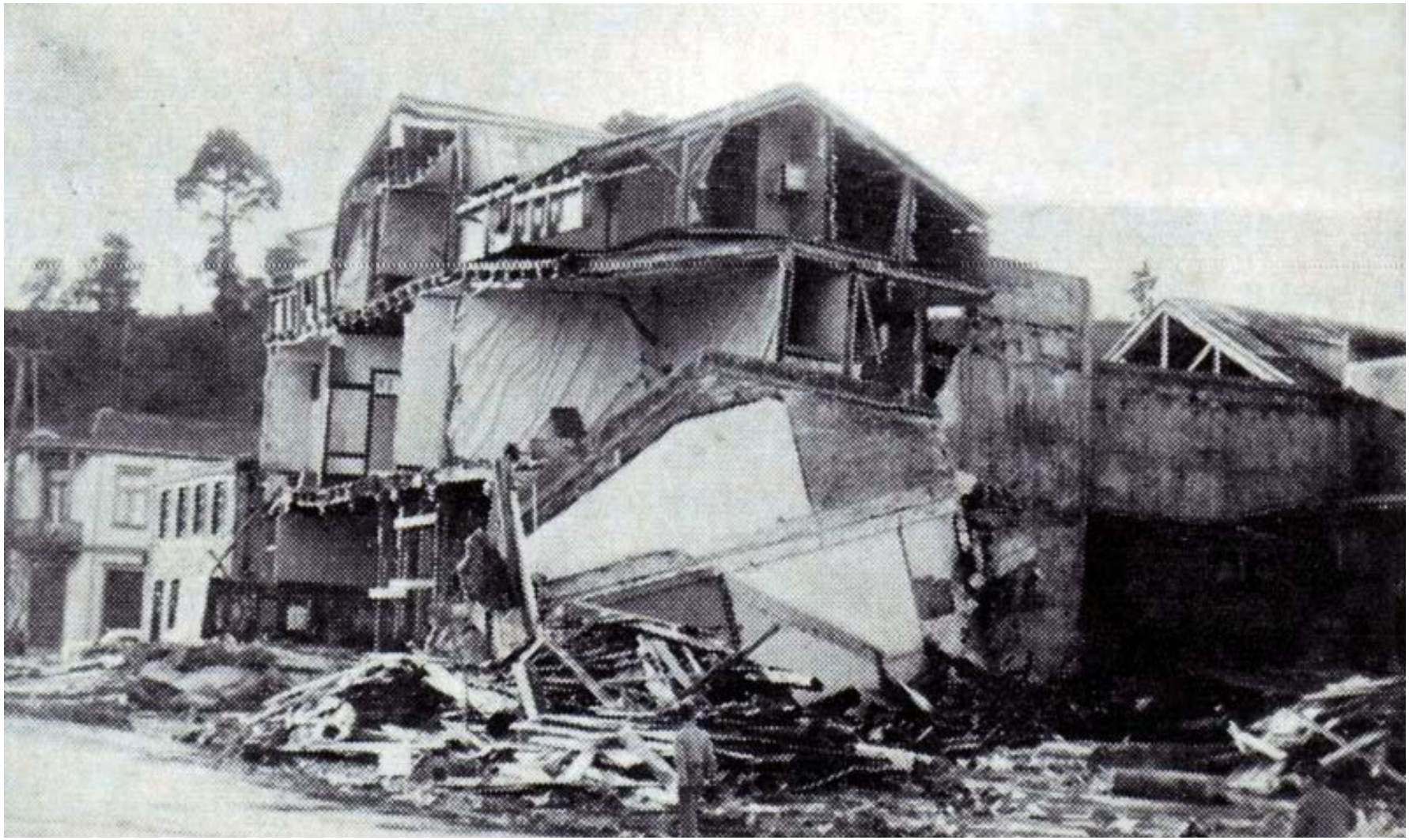
magnitude

Pos.	Date	Location	Magnitude
1	1960-05-22 (May 22, 1960)	Valdivia, Chile (see: 1960 Valdivia earthquake)	9.5
2	2004-12-26 (December 26, 2004)	Off west coast of northern Sumatra, Indonesia (see: 2004 Indian Ocean earthquake)	9.3
3	1964-03-27 (March 27, 1964)	Prince William Sound, Alaska, USA (see: 1964 Alaska earthquake)	9.2
4	1952-11-04 (November 4, 1952)	Kamchatka, USSR (see: Kamchatka earthquakes)	9.0 [1][2]
5	1700-01-26 (January 26, 1700)	Cascadia subduction zone (see: 1700 Cascadia earthquake)	~9
6	1906-01-31 (January 31, 1906)	Colombia-Ecuador	8.8
7	1965-02-04 (February 4, 1965)	Rat Islands, Alaska, USA	8.7
8	1833-11-25 (November 25, 1833)	Sumatra, Indonesia (see: 1833 Sumatra earthquake)	8.8-9.2
9	1755-11-01 (November 1, 1755)	Lisbon, Kingdom of Portugal (see: 1755 Lisbon earthquake)	~8.7
10	2005-03-28 (March 28, 2005)	Sumatra, Indonesia	8.6-8.7*

10	2005-03-28 (March 28, 2005)	Sumatra, Indonesia	8.6-8.7*
11	1957-03-09 (March 9, 1957)	Andreanof Islands, Alaska, USA (see: 1957 Andreanof Islands earthquake)	8.6
12	1920-12-16 (December 16, 1920)	Ningxia-Gansu, China	8.6
13	1950-08-15 (August 15, 1950)	Assam, India - Tibet, China (see: 1950 Medog earthquake)	8.6
14	1575-12-16 (December 16, 1575)	Valdivia, Kingdom of Chile	8.5
15	2007-09-12 (September 12, 2007)	Sumatra, Indonesia	8.5
16	1737-10-16 (October 16, 1737)	Kamchatka, Russian Empire (see: Kamchatka earthquakes)	~8.3



1960 Valdivia Chile Earthquake



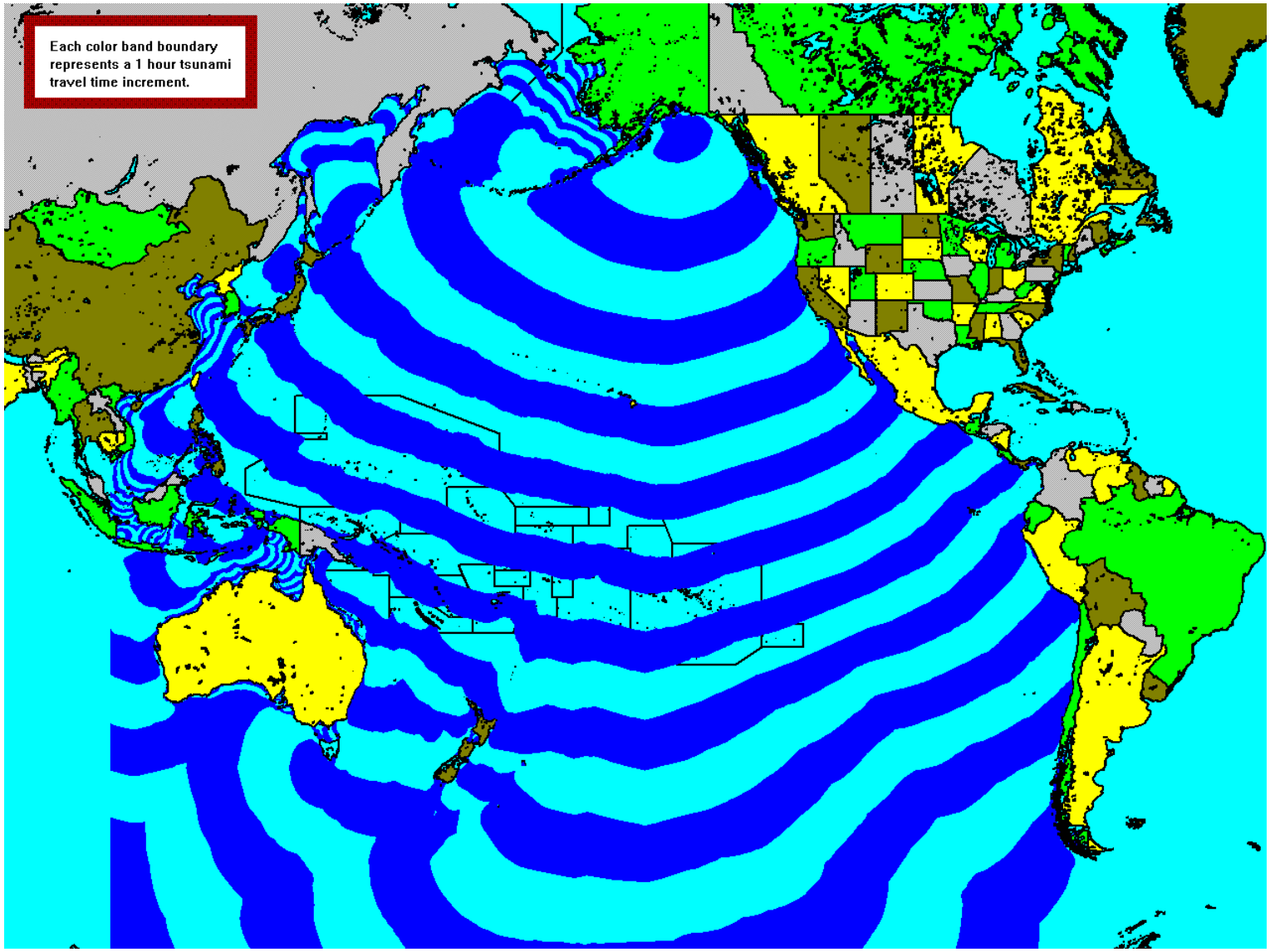
Other locations where earthquakes were triggered by the 10 minutes worth of shaking

2004 Indian Ocean Earthquake

December 26, 2004

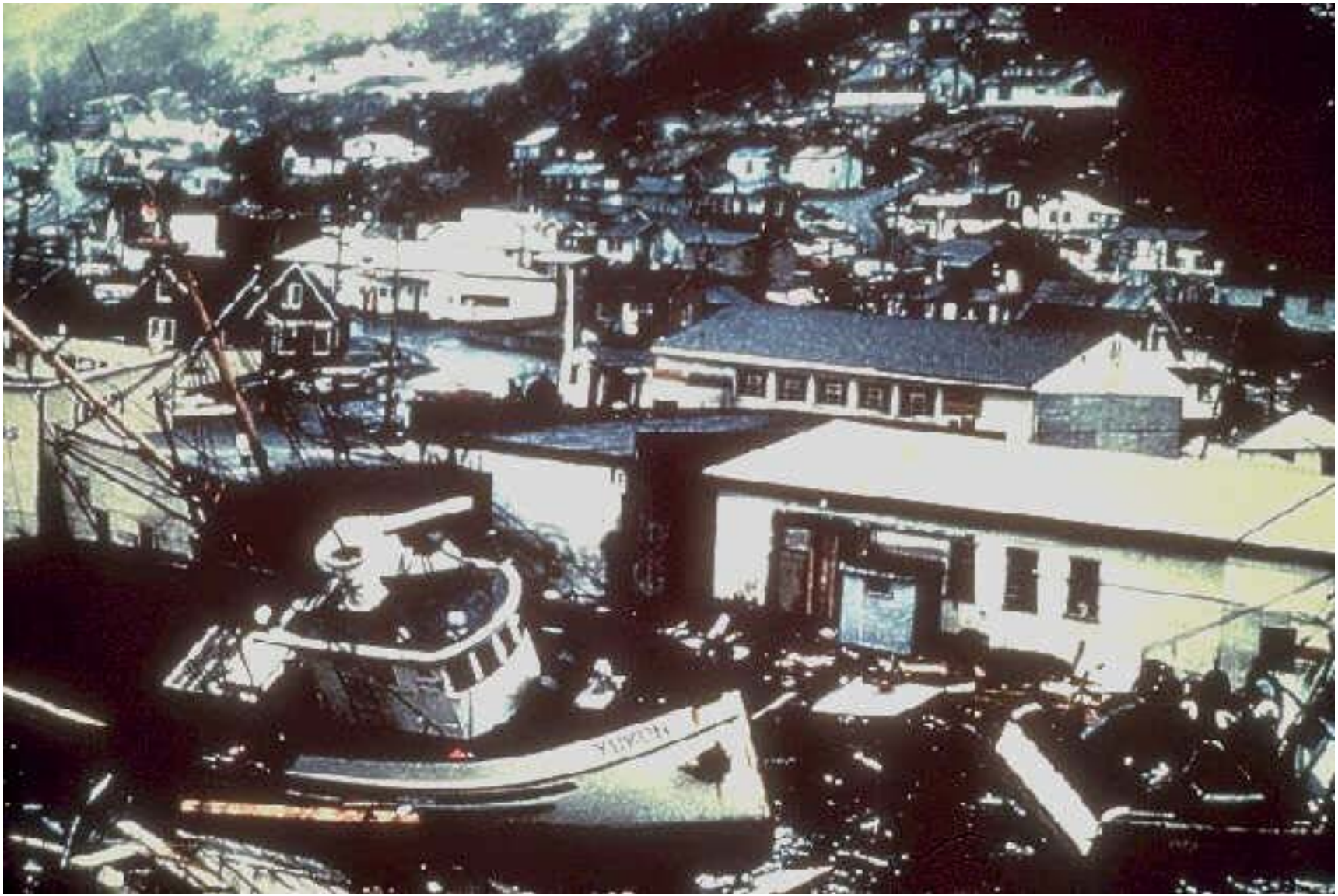
January 1, 2004

1964 Alaskan Earthquake


Each color band boundary represents a 1 hour tsunami travel time increment.


LIFE
2NeatBooks.com

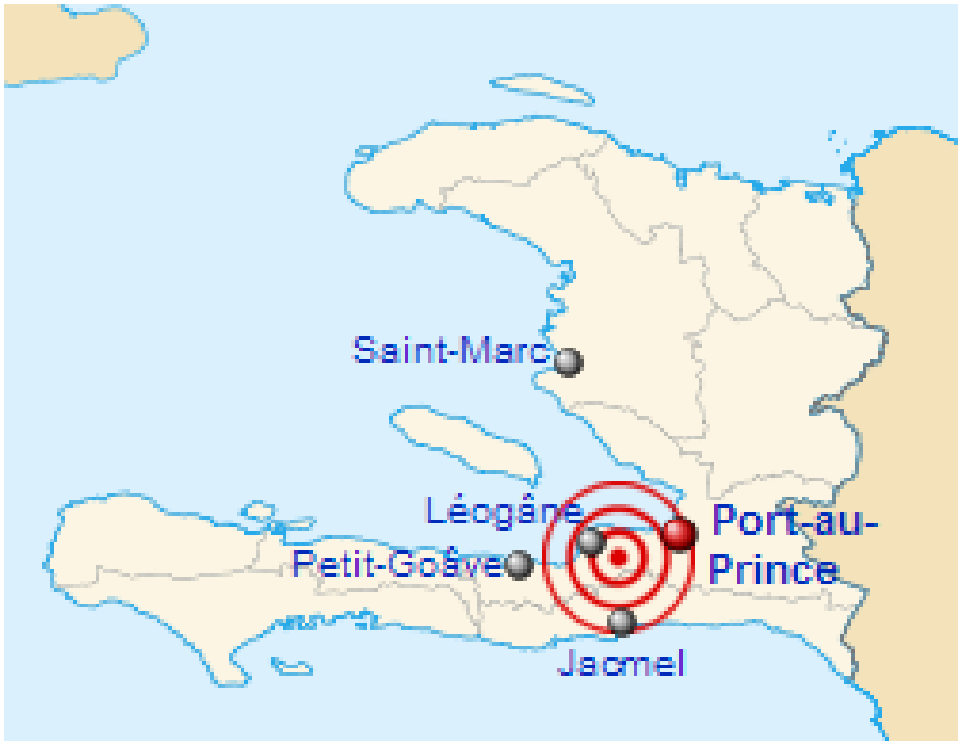
Damage from 1964 Good Friday Earthquake at Turnagain Arm, Anchorage Credit: NOAA



1906 San Francisco Earthquake

The fire that resulted from the 1906 SF Earthquake

2010 Haitian Earthquake



-18.457°N 72.533°W

-Magnitude 7.0, w/ 52+ aftershocks

-Enriquillo-Plantain Garden Fault System, where the Caribbean plate slides across the edge of the North American

-Affected 3 million people,

~230,000 dead, 300,000 injured

-destroyed 250,000 residences, 30,000 commercial bldgs

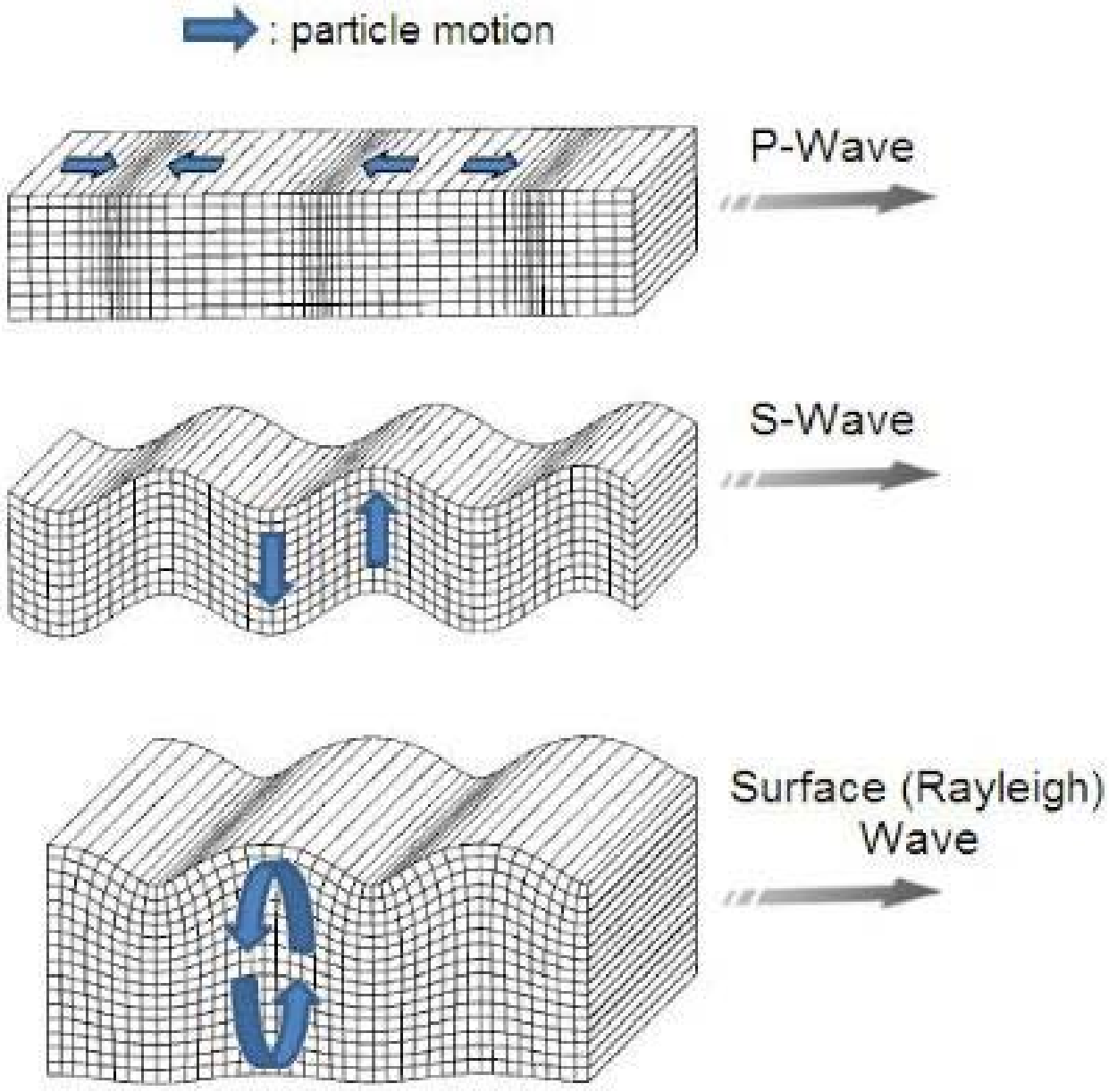

Charly
RESTO DANSANT
PIQUI

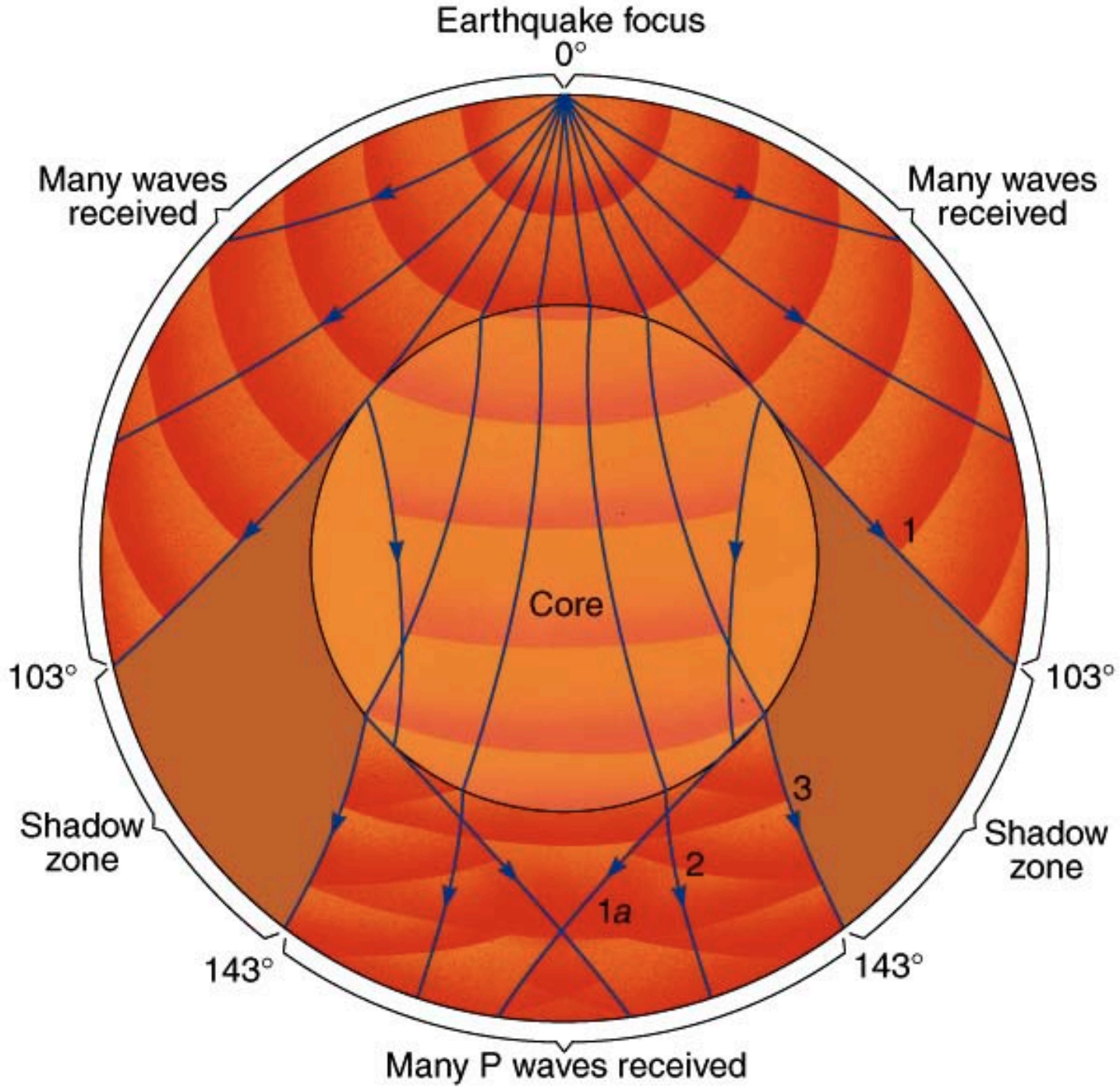
Seismic Waves

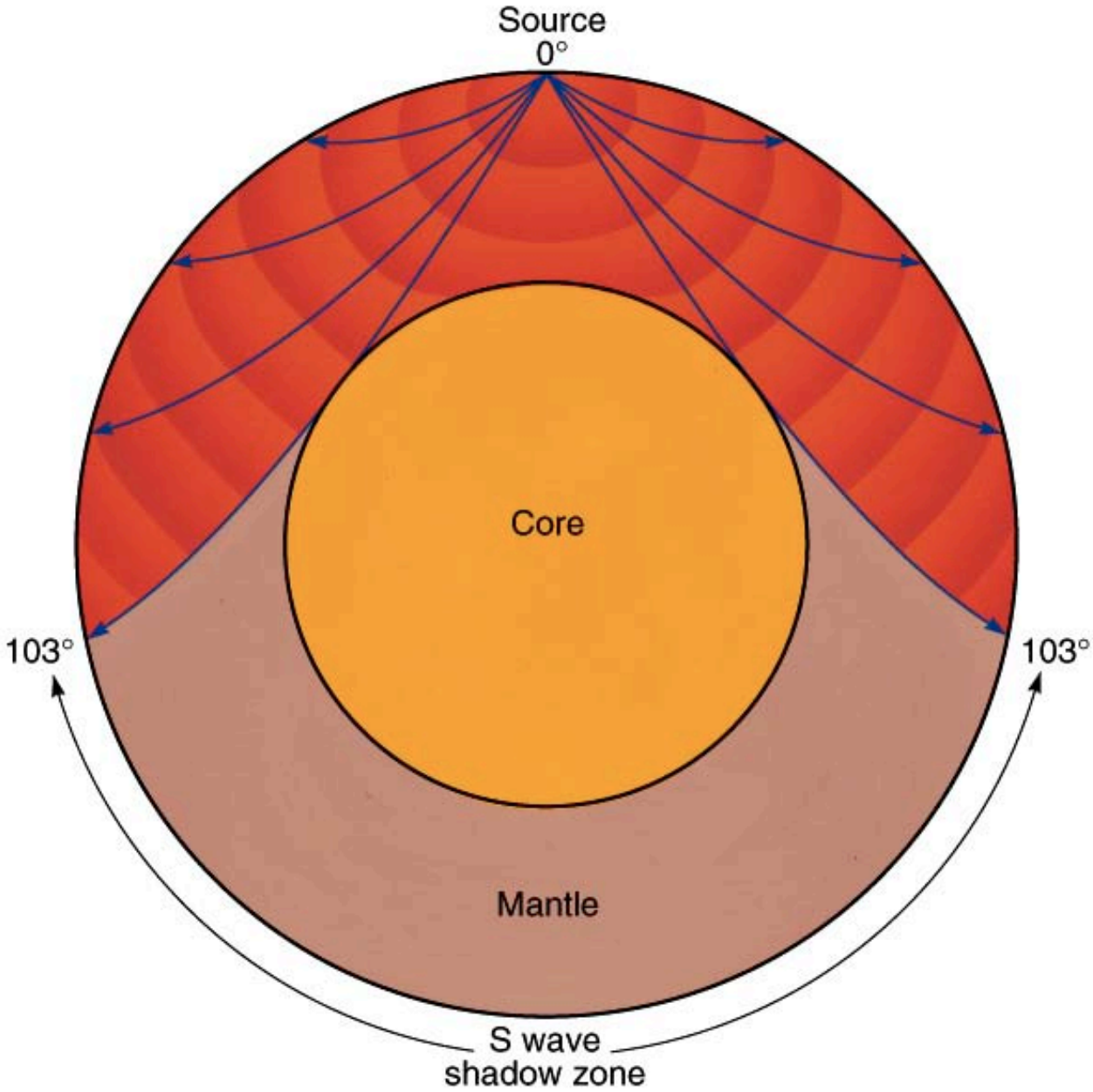
P Waves(Primary Waves)- Fastest wave, can travel through any medium, compression wave

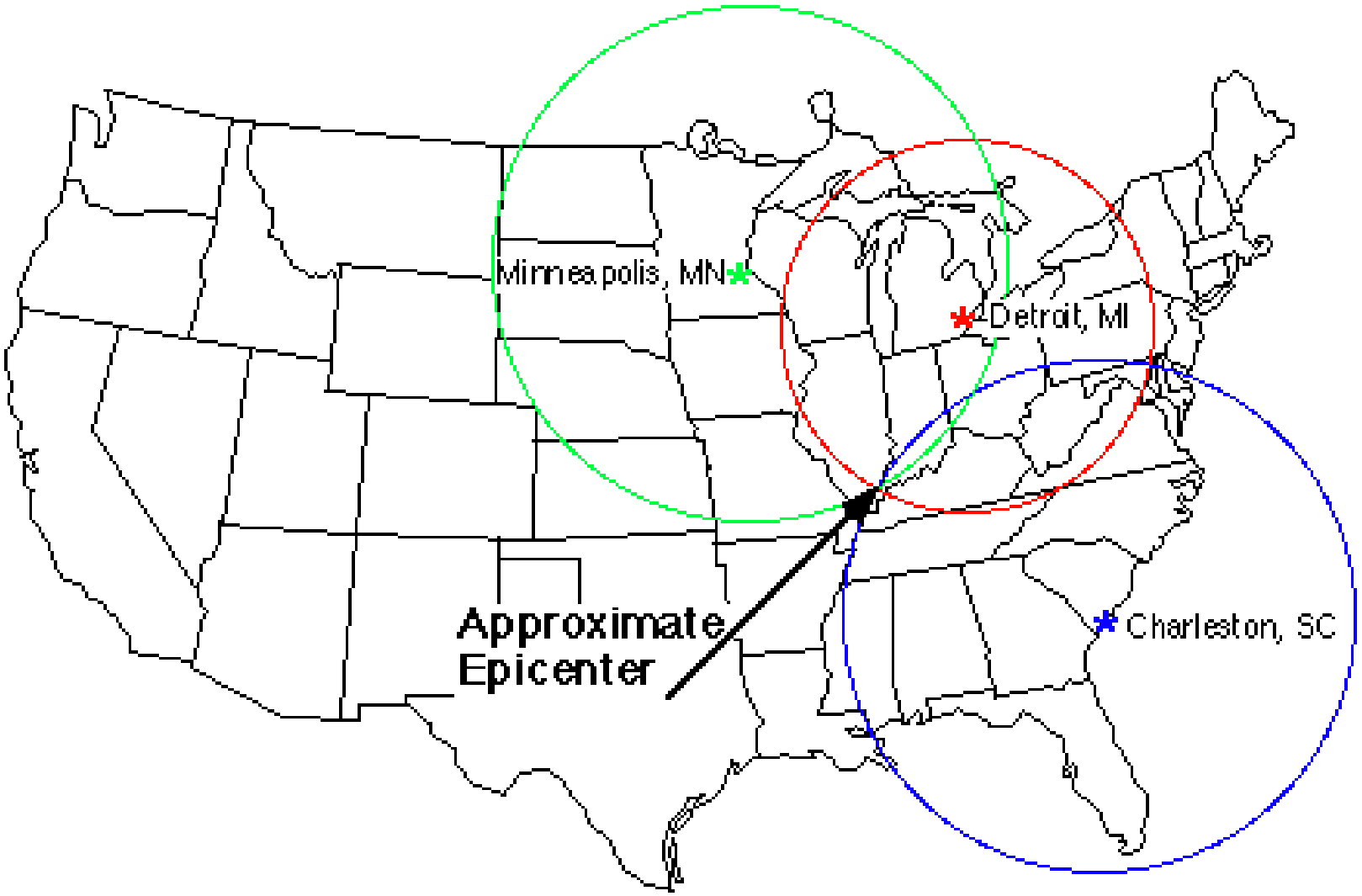
S Waves (secondary/ shear waves)- second fastest wave, transverse waves, can't travel through liquids

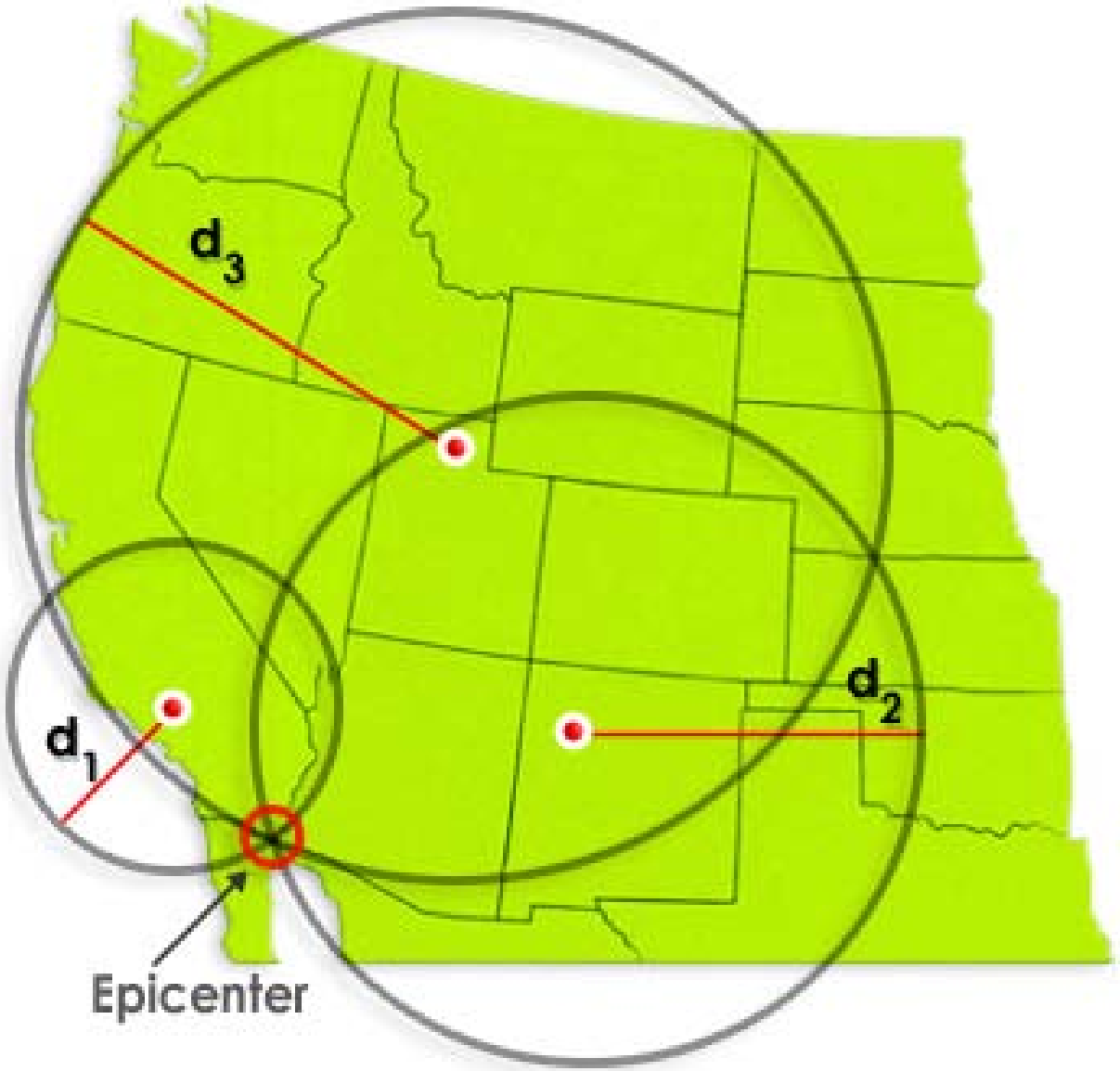
Surface Waves- forms where two different media meet (rock & air), the most damaging waves of an earthquake


: particle motion
P-Wave
S-Wave
Surface (Rayleigh) Wave


Earthquake focus
0°
Many waves received
Many waves received
Core
1
103°
103°
3
Shadow zone
Shadow zone
2
1a
143°
143°
Many P waves received


Source
0°
Core
103°
103°
Mantle
S wave
shadow zone


Minneapolis, MN
Detroit, MI
Charleston, SC
Approximate
Epicenter


d_3
d_1
d_2
Epicenter