
بسم الله الرحمن الرحيم

GEO 435

Oceanography

Dr. Sattam Abdulkareem Almadani

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- Ph.D. (2011) Geophysics, Missouri University of Science & Technology (MST), Rolla, Missouri, USA.
- M.S. (2003) Marine Physics, King Abdulaziz University (KAAU), Jeddah.
- B.S. (1999) Marine Physics, King Abdulaziz University (KAAU), Jeddah.

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Meeting Time:

Mon 1:00 – 2:50 pm

Credits:

2 hours (2+0)

Reference Books:

- Essentials of Oceanography by Alan Trujillo and Harold Thurman, Eight Edition (2005).
- Exploring Ocean Science by Keith Stowe, Second Edition (1996).

Objectives:

- ❑ Iintroduction.
- ❑ Physical processes in the oceans.
- ❑ Waves, currents and tides.
- ❑ Formation of ocean basins.
- ❑ Turbidity and deep sediment transport.
- ❑ Earthquakes and tsunamis.
- ❑ Marine chemistry.
- ❑ Coastal processes.
- ❑ Life in the oceans.
- ❑ Ocean minerals resources.
- ❑ Changes in the oceanic ecosystem.

Learning Goals:

By the end of this course, students will:

- Develop basic knowledge about marine science.
- Build up and recognize how oceans work.
- Analyse the important physical processes in the ocean.
- Be familiar with vocabulary related to marine science and ocean exploration.
- Recognize and evaluate recent ocean topics in the media.

Grades:

Based on examinations and class participation

as follows:

- Midterm Exam 1 15%
- Midterm Exam 2 15%
- Final Exam 40%
- In-class quizzes 10%
- Attendance and participation 10%
- Homework assignments 10%

What I need from you:

- Your attendance:
  - Never to be late more than 10 minutes before lecture
  - Never play with your cell phone while giving lecture.
  - Never talk to your friend while giving lecture.
  - Never miss more 25% of the total lectures.
- Your participation:
  - Involve in all group discussions and activities.
  - Write down all important information in your notebook.
- Homework assignments:
  - Answer all your homework assignments on-time.
  - Never cheat from others.

My advice to you:

- Group study.
- Ask questions.
- Don't copy.
- Arrange your time.
- Always prepare a plan to achieve your targets.

Any questions?

Introduction to Planet "Earth":

- What is Oceanography.
- Divisions of Oceanography.
- The Four Principal Oceans, Plus One.
- The Seven Seas.
- The Difference Between Sea and Ocean.
- Age of the Earth.
- Radius of the Earth.
- Earth's Internal Structure.
- Difference Between Continental Crust and Oceanic Curst.

Q. What is Oceanography?

Ocean = the marine environment

graphy = the name of a descriptive science

Definition: Oceanography is the scientific study of all aspects of the marine environment.

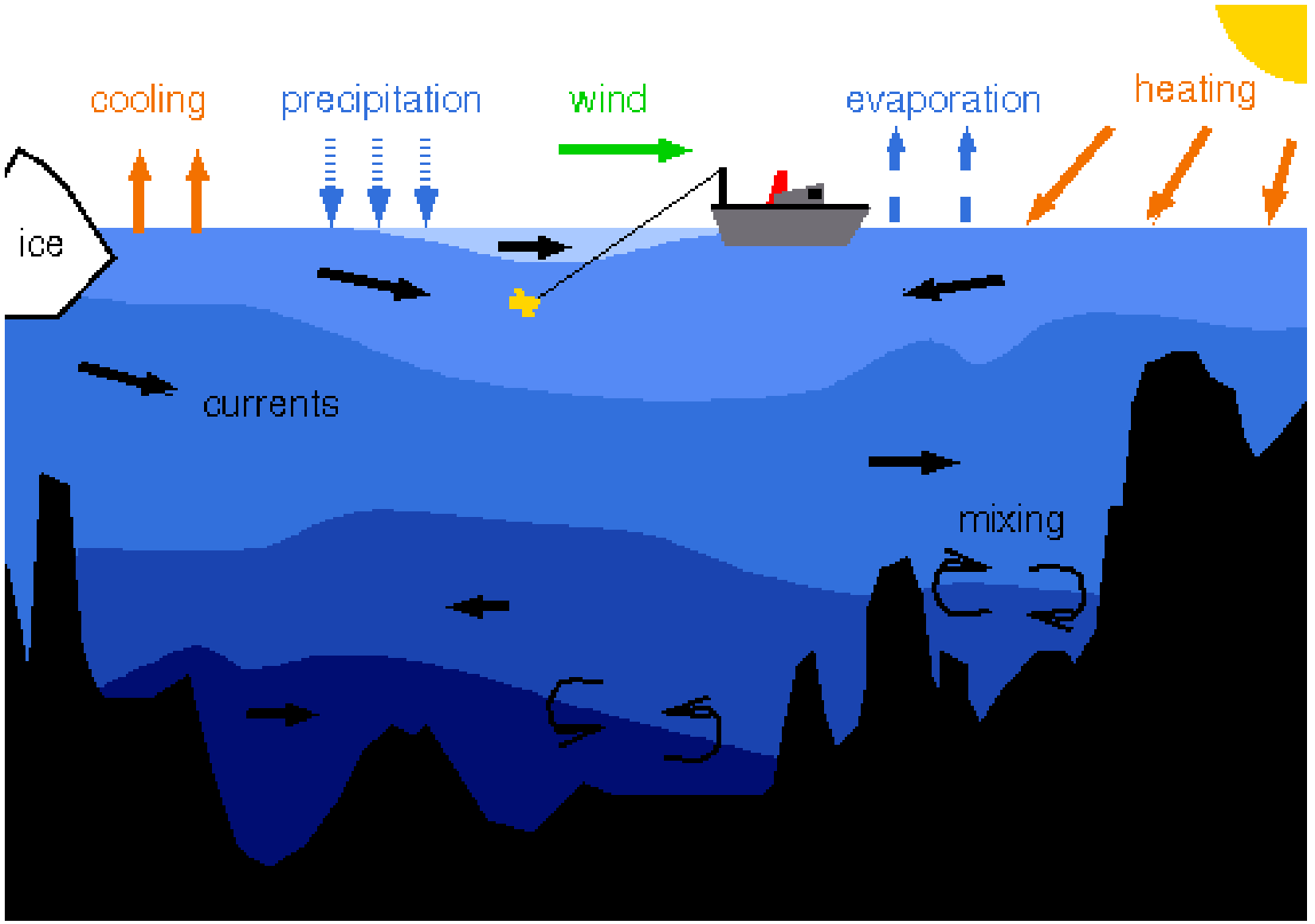
Oceanography = Oceanology = Marine Science

Marine Science study:

1. The water of the ocean.

2. The life within the ocean.

3. The solid Earth beneath the ocean.


cooling
precipitation
wind
evaporation
heating
ice
currents
mixing

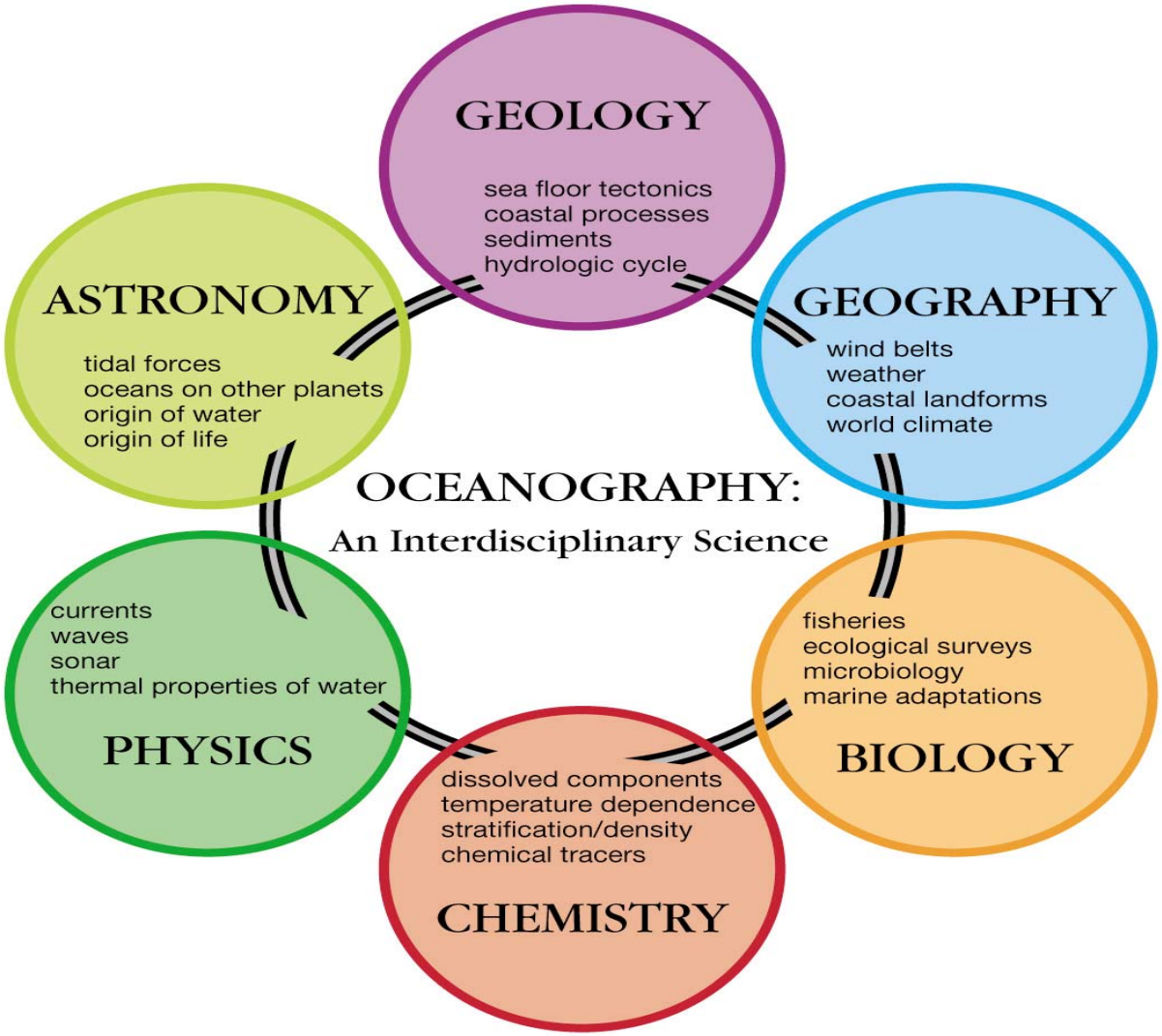
Divisions of Oceanography:

1. Geological Oceanography (Marine Geology): study the structure of sea floor.

2. Chemical Oceanography (Marine Chemistry): study the chemical composition and properties of seawater.

3. Physical Oceanography (Marine Physics): study the waves, tides, and currents.

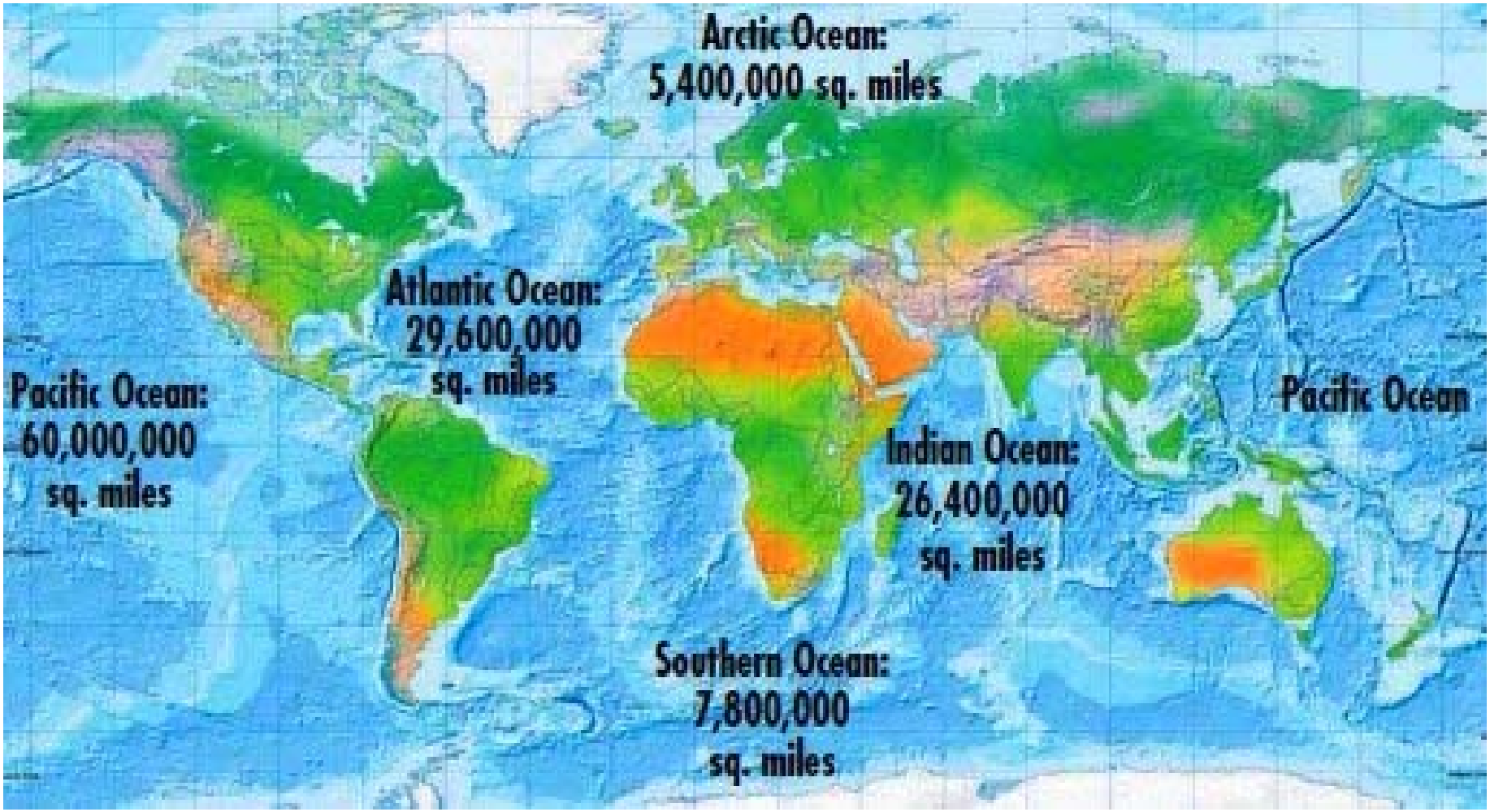
4. Biological Oceanography (Marine Biology): study the ocean life.


GEOLOGY
sea floor tectonics
coastal processes
sediments
hydrologic cycle
ASTRONOMY
tidal forces
oceans on other planets
origin of water
origin of life
GEOGRAPHY
wind belts
weather
coastal landforms
world climate
OCEANOGRAPHY:
An Interdisciplinary Science
currents
waves
sonar
thermal properties of water
PHYSICS
fisheries
ecological surveys
microbiology
marine adaptations
BIOLOGY
dissolved components
temperature dependence
stratification/density
chemical tracers
CHEMISTRY

The Four Principal Oceans, Plus One:

Our world ocean can be divided into four principal oceans (plus an additional ocean) based on the shape of the ocean and the positions of the continents. They are:

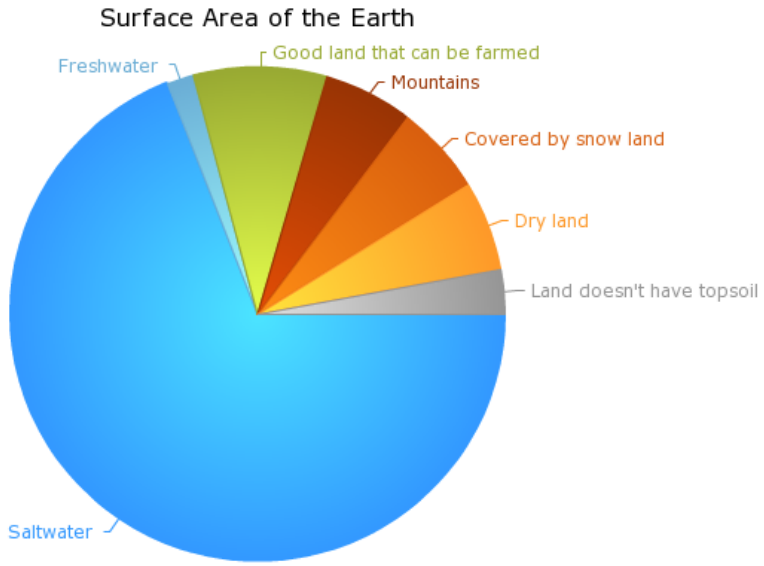
1. Pacific Ocean.
2. Atlantic Ocean.
3. Indian Ocean.
4. Arctic Ocean.
5. Southern Ocean or Antarctic Ocean.


Arctic Ocean:
5,400,000 sq. miles
Atlantic Ocean:
29,600,000
sq. miles
Pacific Ocean:
60,000,000
sq. miles
Indian Ocean:
26,400,000
sq. miles
Pacific Ocean
Southern Ocean:
7,800,000
sq. miles

Earth's Surface:

Land (29.2%)

Ocean (70.8%)



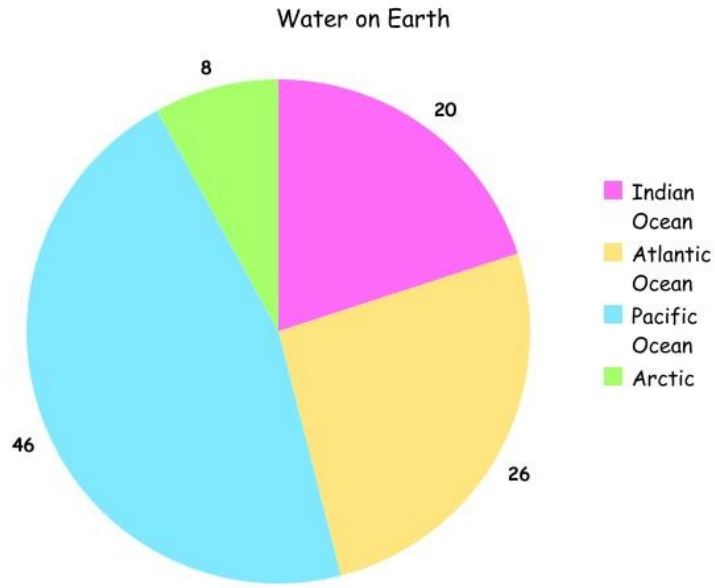
Ocean Size:

Pacific (50%)

Atlantic (26%)

Indian (20.5%)

Arctic (3.4%)



The Seven Seas:

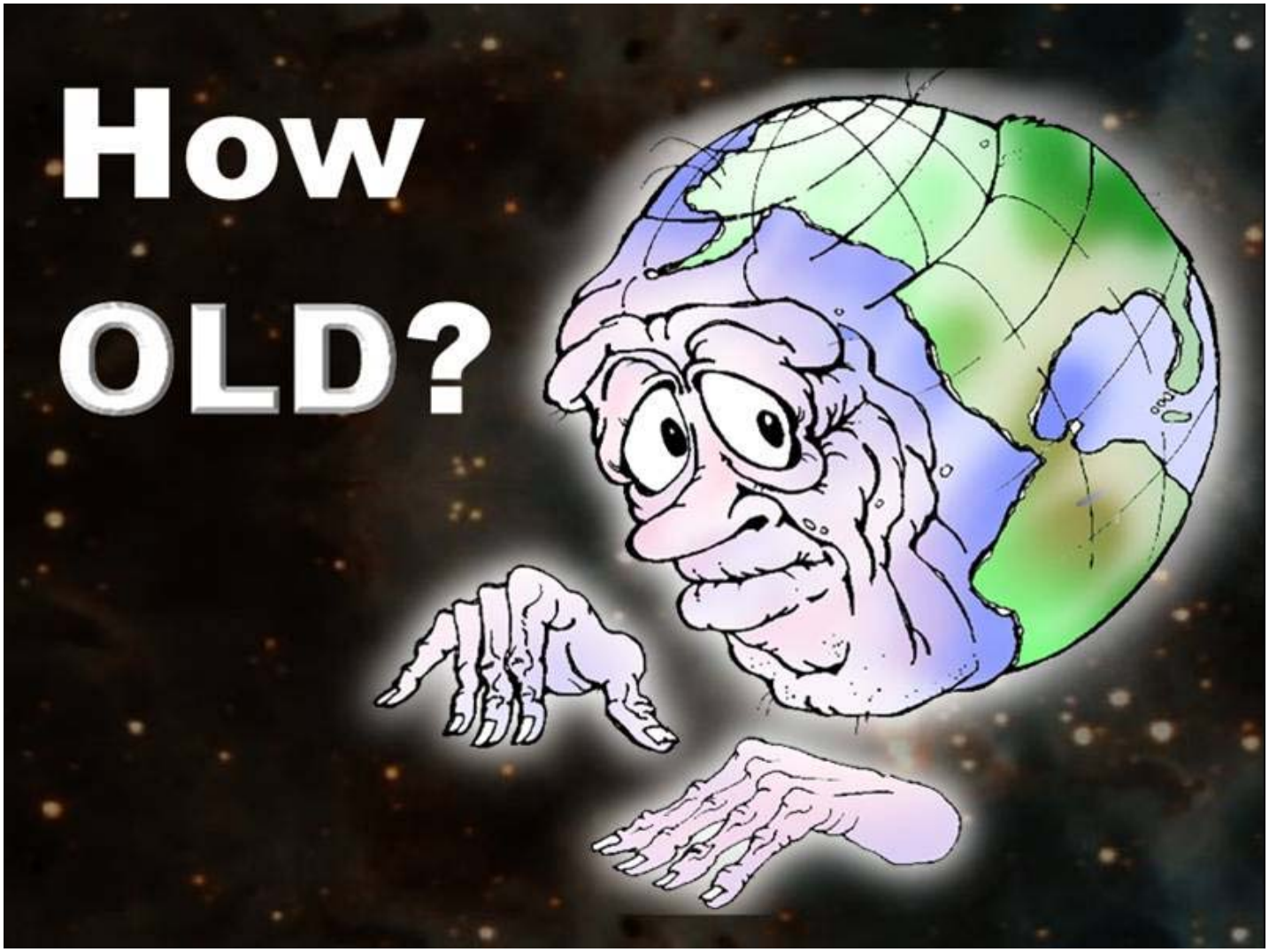
1. the North Pacific.
2. the South Pacific.
3. the North Atlantic.
4. the South Atlantic.
5. the Indian.
6. the Arctic.
7. the Southern or Antarctic.


Arctic Ocean
North Pacific Ocean
North Atlantic Ocean
North Pacific Ocean
Indian Ocean
South Pacific Ocean
South Atlantic Ocean
Antarctic Ocean
Antarctic Ocean

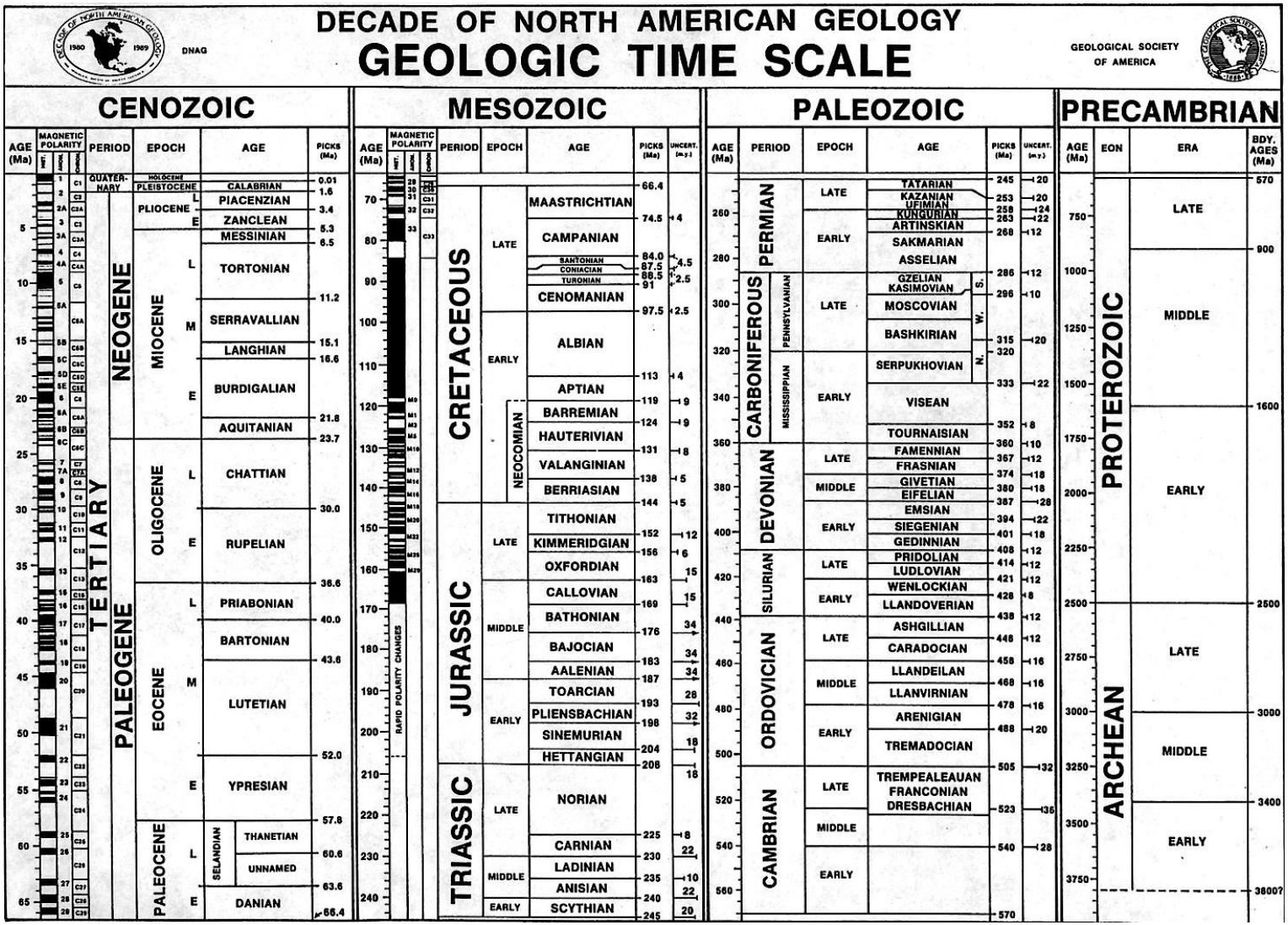
Q. What is the difference between sea and ocean?

Sea	Ocean
Cover small area	Cover large area
Small in size	Large in size
Shallower	Deeper
Enclosed boundaries	Open boundaries

Q. How old is Earth?

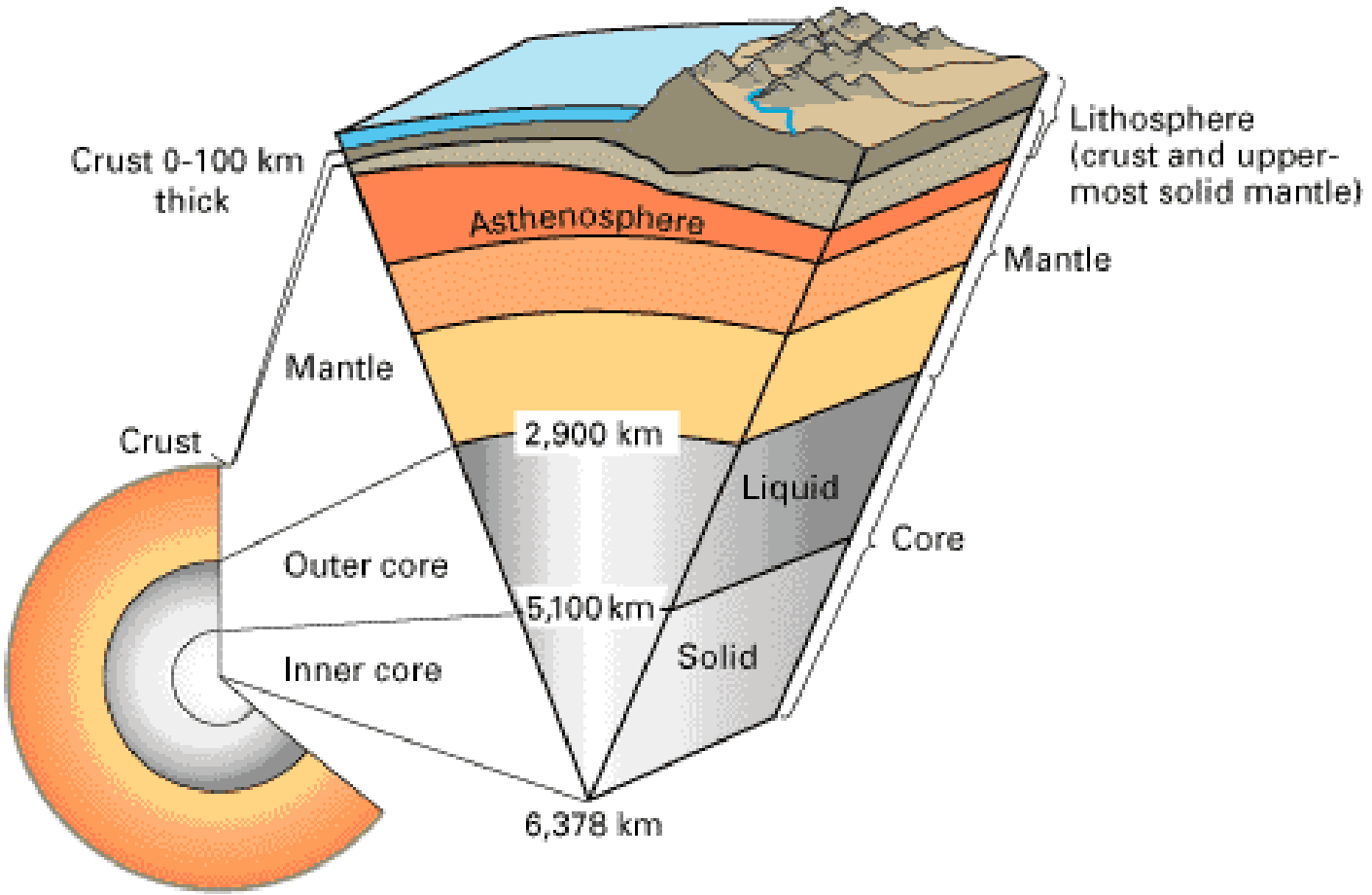


Based on the radiometric age dating, Earth is 4.6 billion years old.



How much is Earth's radius?

Earth radius is the distance from Earth's center to its surface which is about 6378 km (3959 mi).



Earth's Internal Structure:

Earth's inner structure can be subdivided according to:

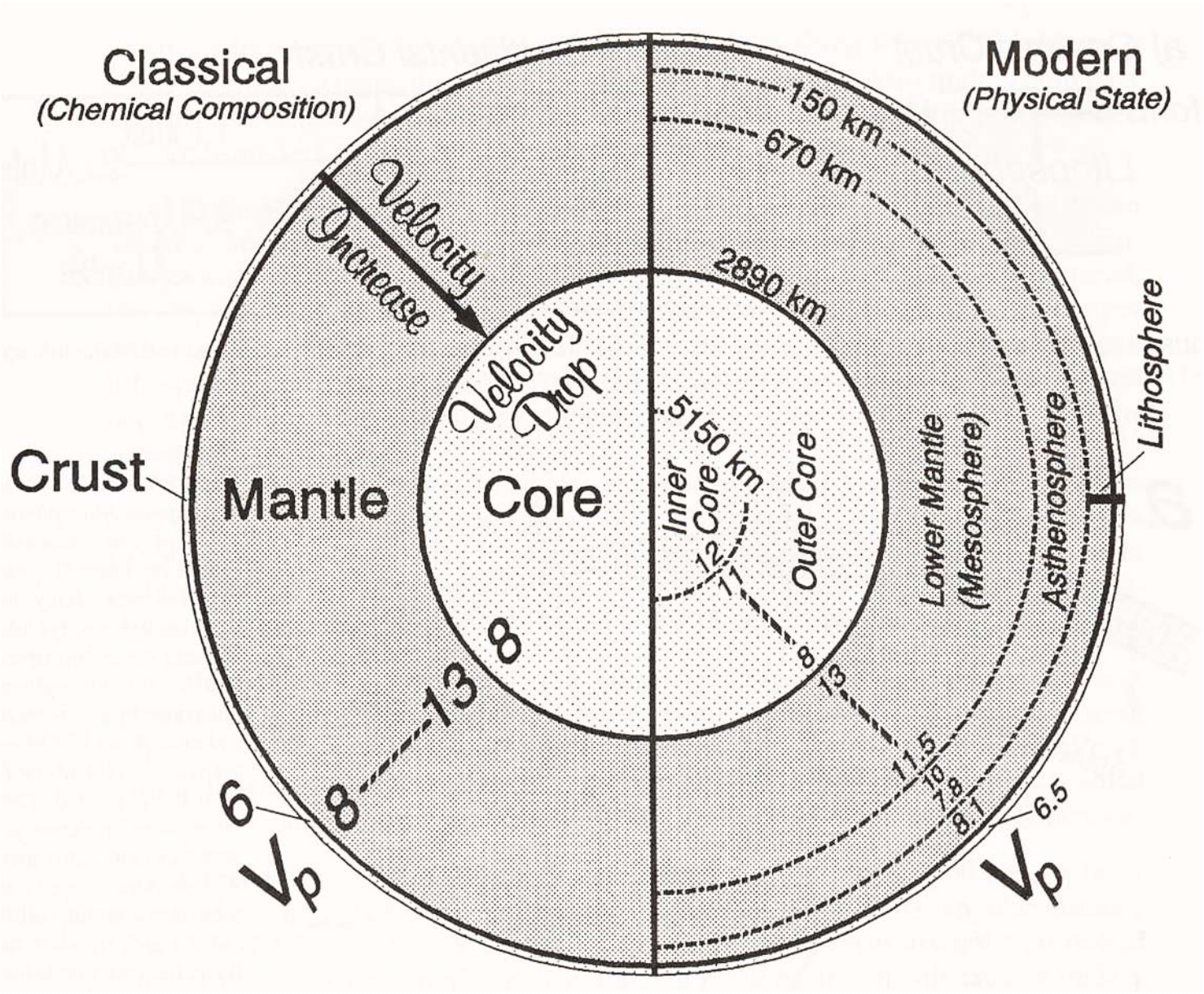
1. Chemical composition: the chemical composition of Earth materials.
2. Physical properties: how the rocks respond to increased temperature and pressure at depth.

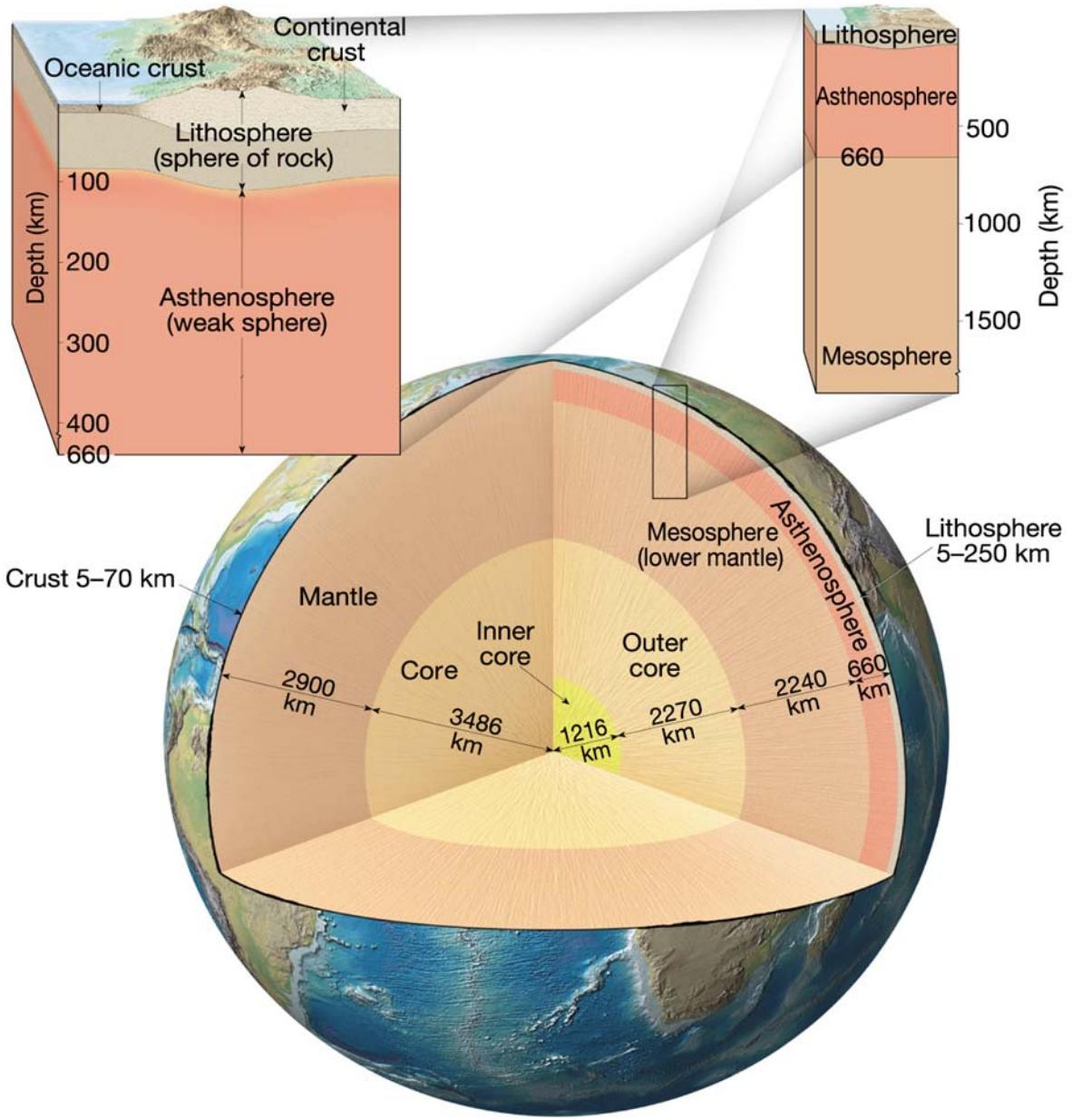
Layers defined by chemical composition:

1. Crust
2. Mantle
3. Core

Layers defined by physical properties:

1. Lithosphere
2. Asthenosphere
3. Mesosphere
4. Inner and outer core.


Classical
(Chemical Composition)
Modern
(Physical State)
Velocity Increase
Velocity Drop
150 km
670 km
2890 km
5150 km
Crust
Mantle
Core
Inner Core
Outer Core
Lower Mantle (Mesosphere)
Asthenosphere
Lithosphere
6
8
13
8
12
11
8
13
11.5
10
7.8
8.1
6.5
Vp
Vp


Continental crust
Oceanic crust
Lithosphere (sphere of rock)
100
200
300
400
660
Depth (km)
Asthenosphere (weak sphere)
Lithosphere
Asthenosphere
660
500
1000
1500
Depth (km)
Mesosphere
Mesosphere (lower mantle)
Asthenosphere
Lithosphere 5–250 km
Crust 5–70 km
Mantle
Inner core
Outer core
Core
2900 km
3486 km
1216 km
2270 km
2240 km
660 km

Age of the Earth?

-----4.6 billion years

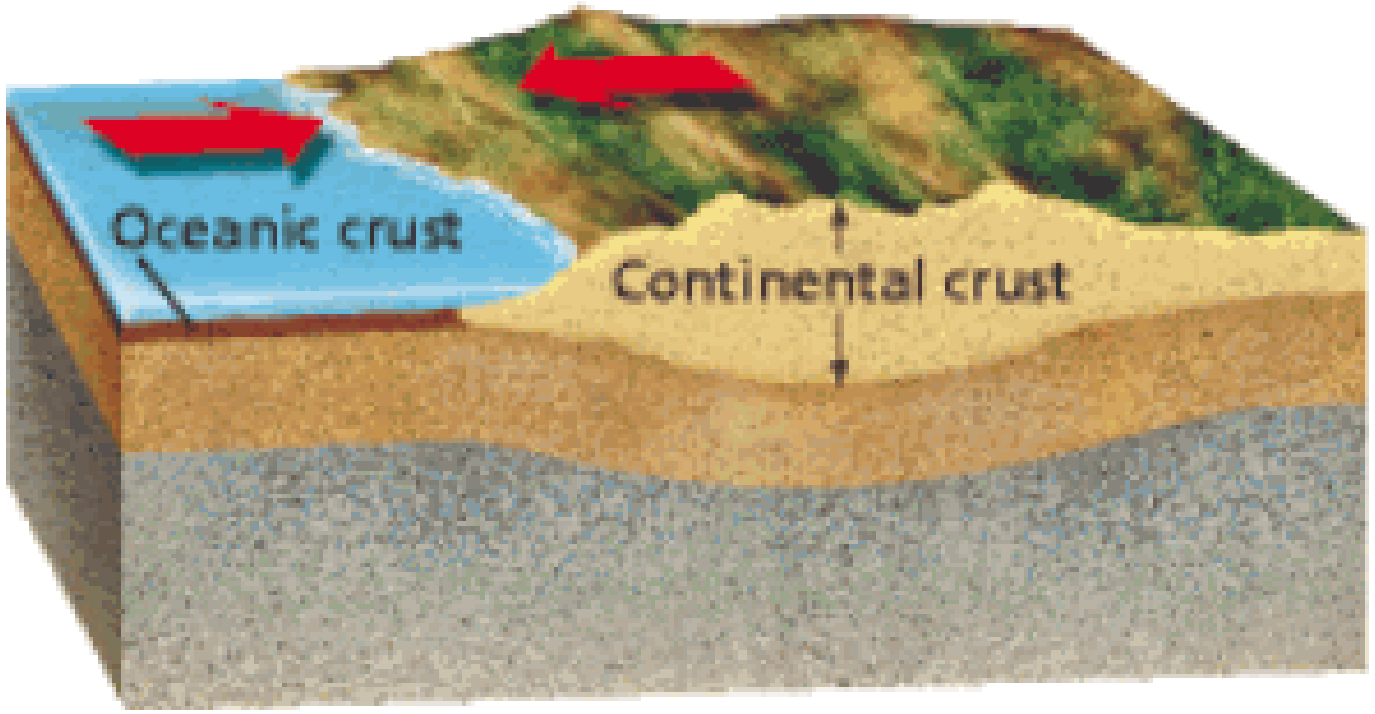
Radius of the Earth?

-----6371 km

Major Layers?

-----Crust, Mantle, Core

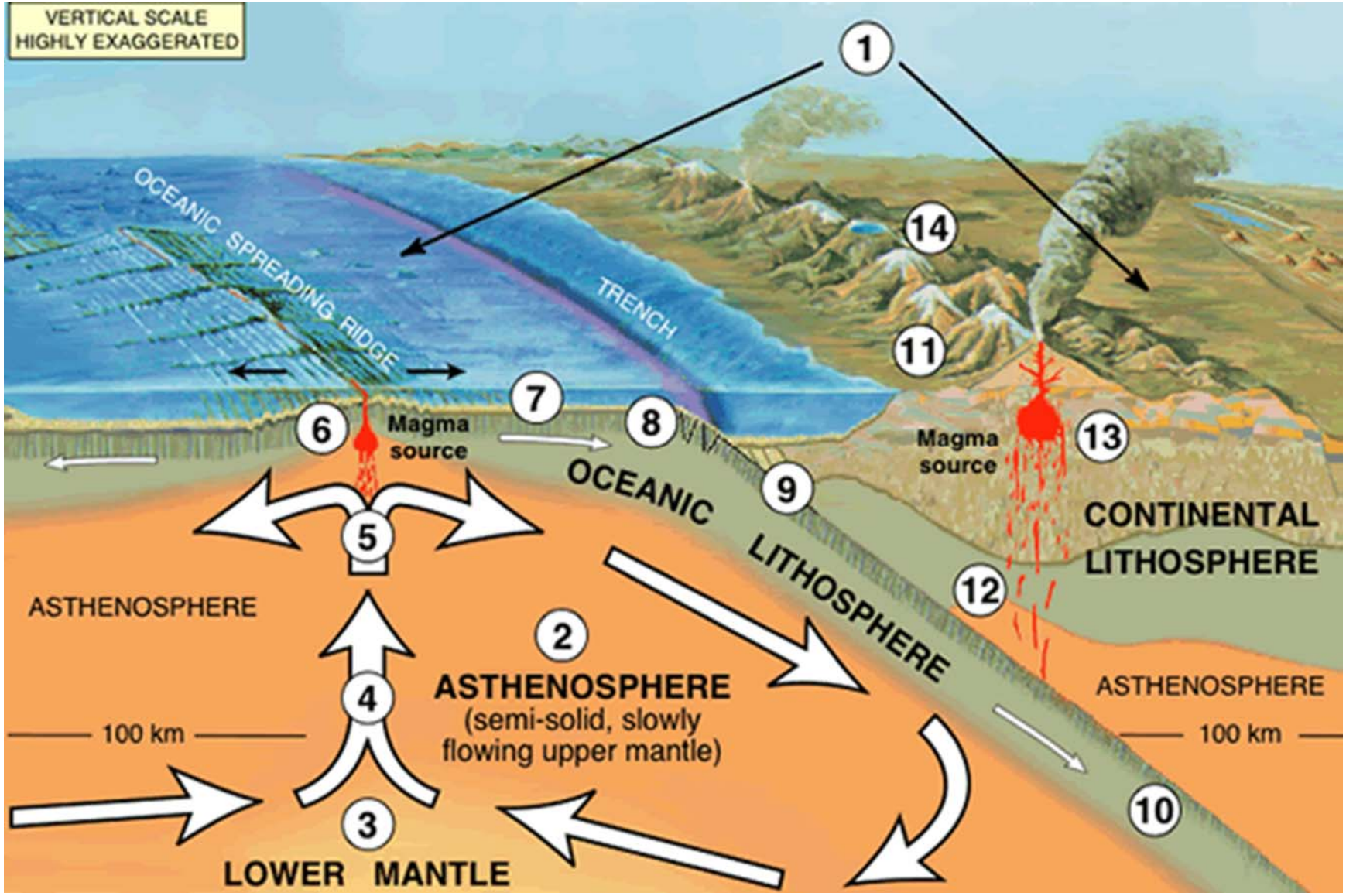
Q. What is the difference between continental crust and oceanic crust?



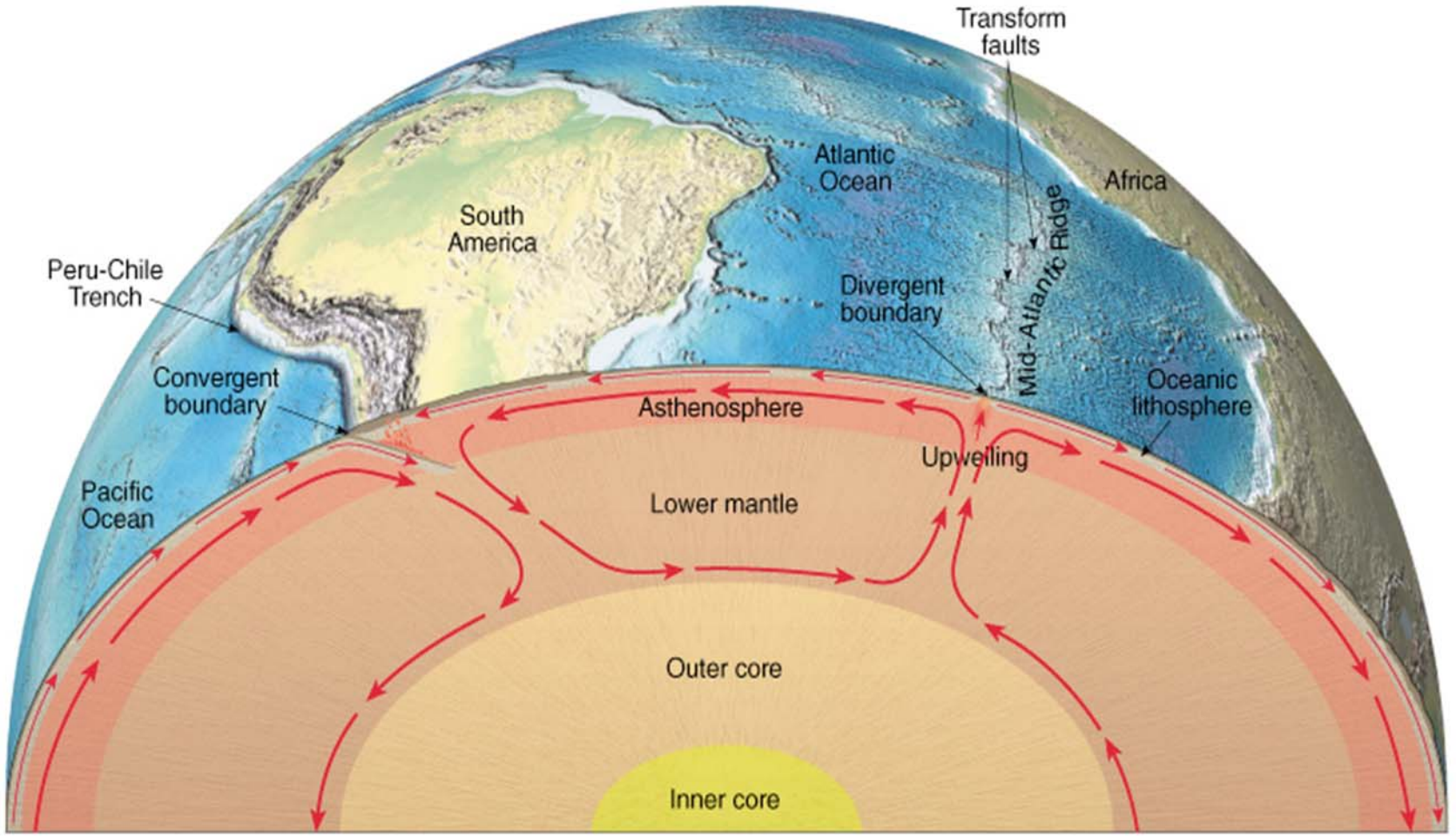
Continental Crust	Oceanic Crust
Thick crust (average 35-40 km)	Thin crust (roughly 7 km thick)
Less dense (2.7 g/cm^3)	More dense (3.0 g/cm^3)
Old (4 Ga years old)	Young (180 Ma years old)
Composed of granitic rocks	Composed of igneous rocks

Plate Tectonics is a theory that explains the following features on Earth:

- Formation of mountain belts, volcanoes, and ocean basins.
- Location of volcanoes, faults, earthquakes, and mountain building.
- Ocean floor features.
- The continuing development of Earth's surface.
- The distribution of past and present life on Earth.


VERTICAL SCALE
HIGHLY EXAGGERATED
1
OCEANIC SPREADING RIDGE
TRENCH
14
11
7
6
Magma source
8
Magma source
13
OCEANIC LITHOSPHERE
9
CONTINENTAL LITHOSPHERE
5
12
ASTHENOSPHERE
2
ASTHENOSPHERE
(semi-solid, slowly flowing upper mantle)
ASTHENOSPHERE
4
100 km
100 km
10
3
LOWER MANTLE

Q. What is the concept of Plate Tectonics?


Transform faults
Atlantic Ocean
Africa
South America
Mid-Atlantic Ridge
Peru-Chile Trench
Divergent boundary
Convergent boundary
Asthenosphere
Oceanic lithosphere
Upwelling
Pacific Ocean
Lower mantle
Outer core
Inner core

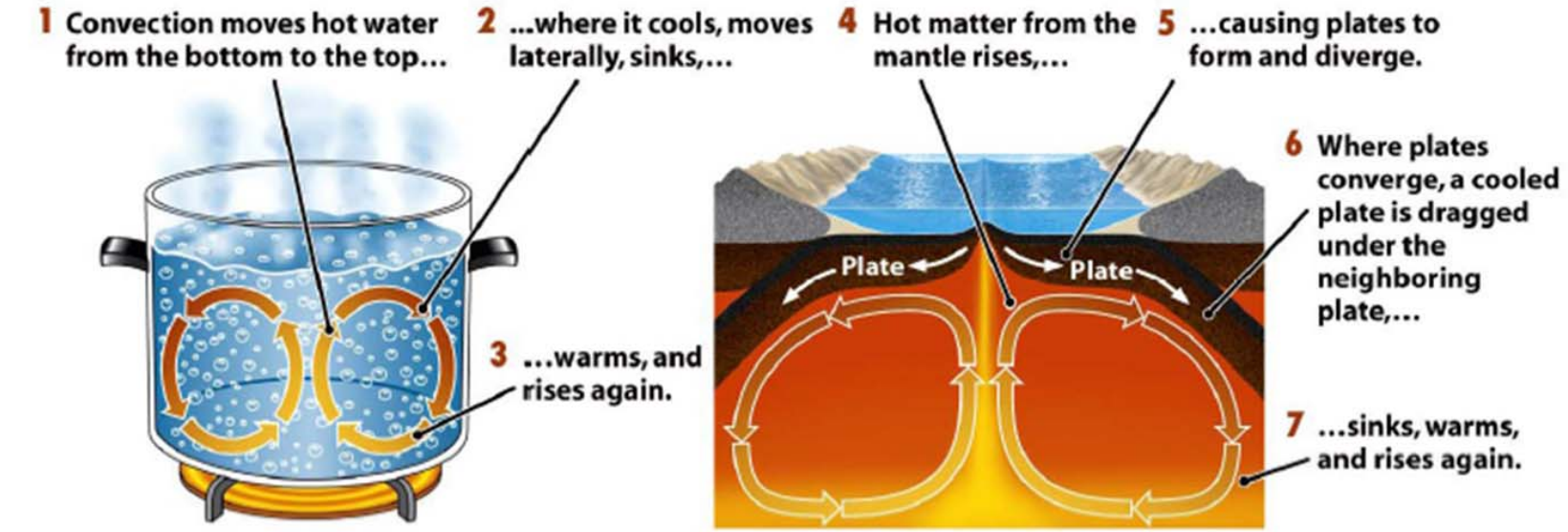
- The outer portion of the Earth is made up of about 20 distinct "plates"(~ 100 km thick), which move relative to each other.

- This motion is what causes earthquakes and makes mountain ranges.

Q. What are the processes of Plate Tectonics?

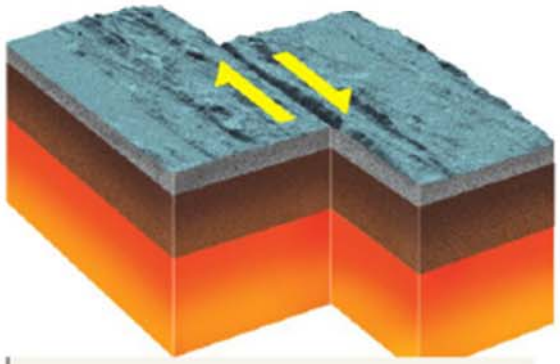
Convection

On the stove *In the mantle*



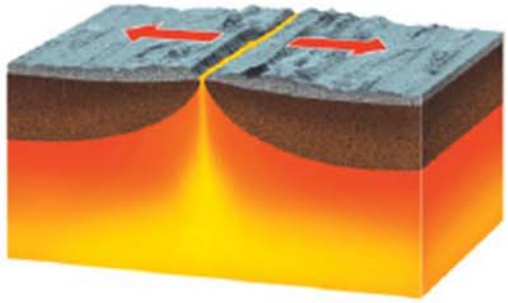
Three Types of Plate Boundaries

Transform



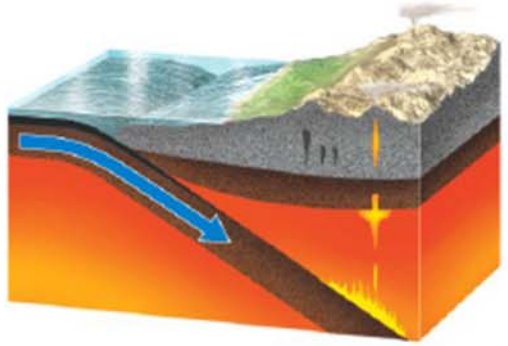
At transform-fault boundaries, plates slide horizontally past each other.

Divergent



At divergent boundaries, plates move apart and create new lithosphere.

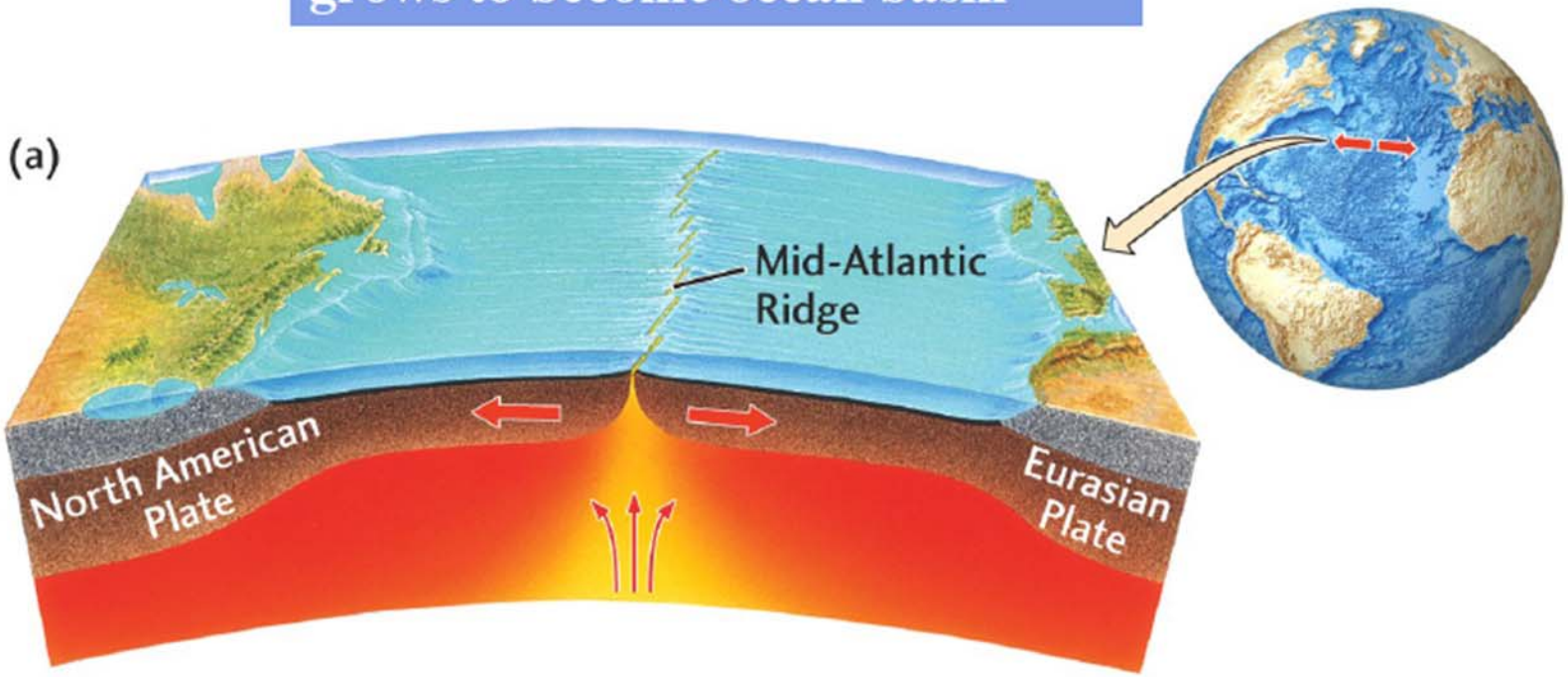
Convergent



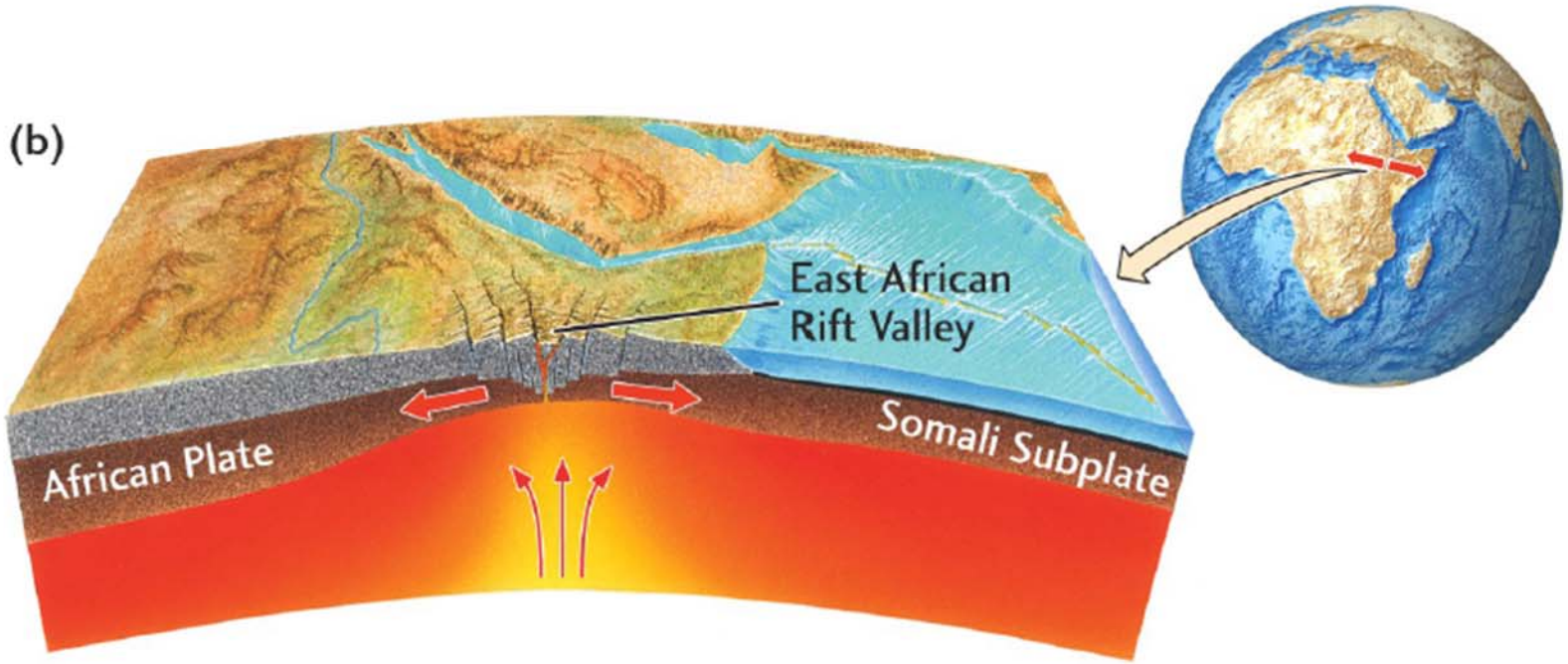
At convergent boundaries, plates collide and one is pulled into the mantle and recycled.

Divergent Plate Boundary

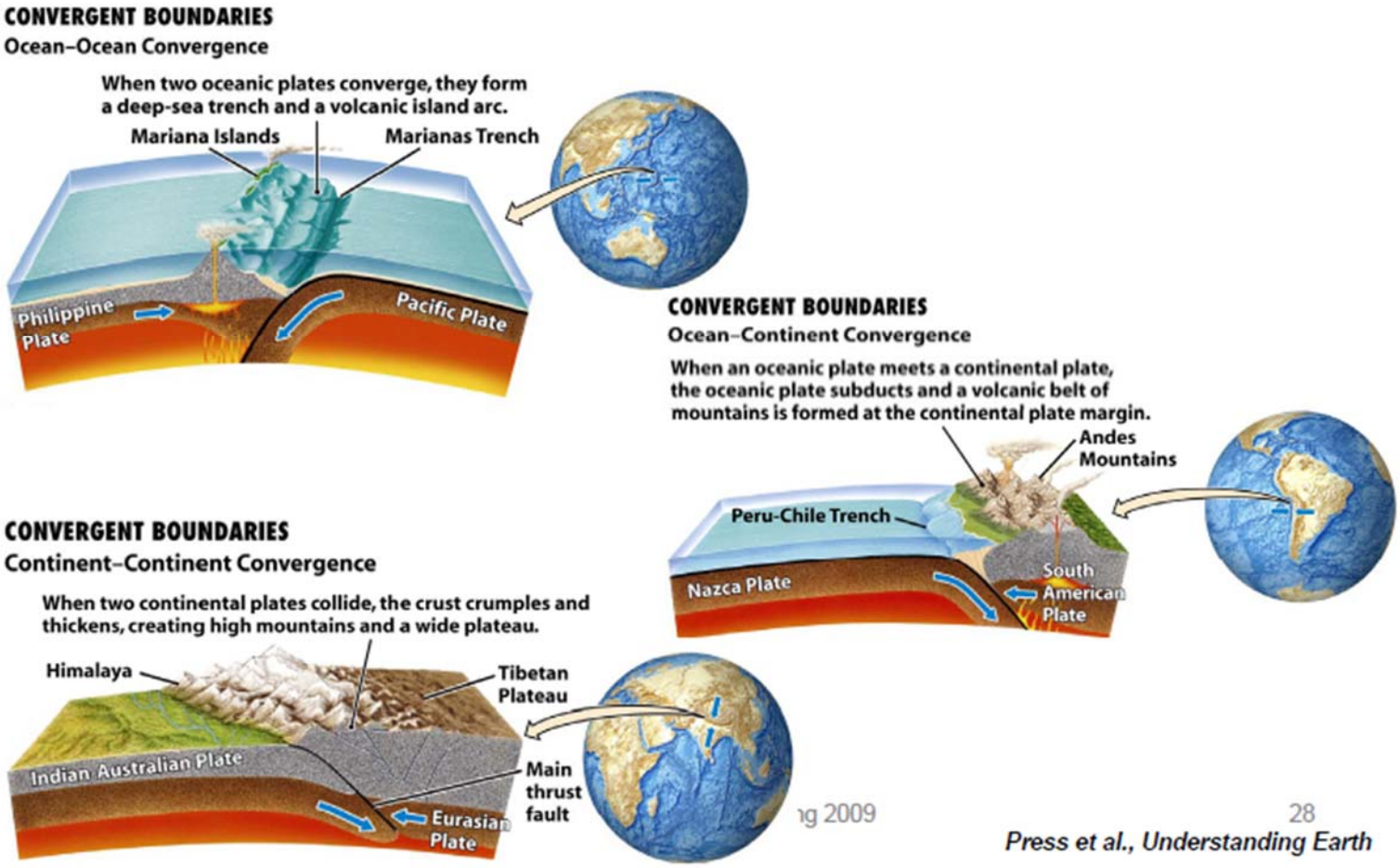
Usually start within continents—grows to become ocean basin



Divergent Plate Boundary



Convergent plate boundary



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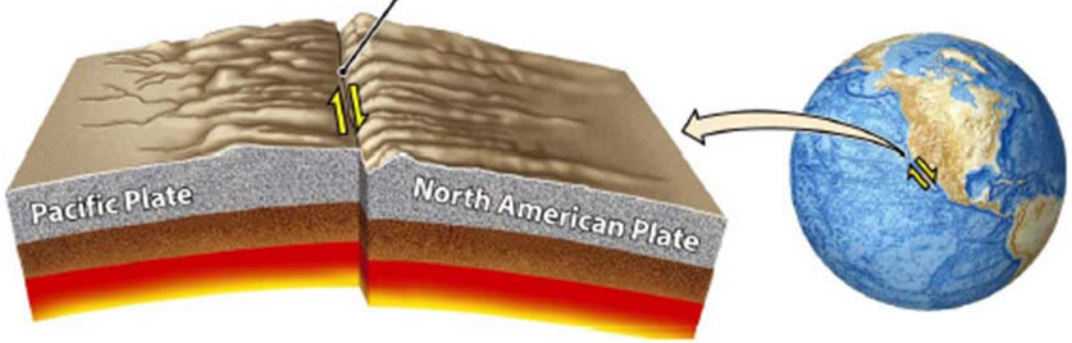
Press et al., Understanding Earth

Transform Plate Boundary

TRANSFORM-FAULT BOUNDARIES
Continental Transform Fault

The San Andreas fault in California, where the Pacific Plate slides past the North American Plate, is an example of a transform fault that offsets continental crust.

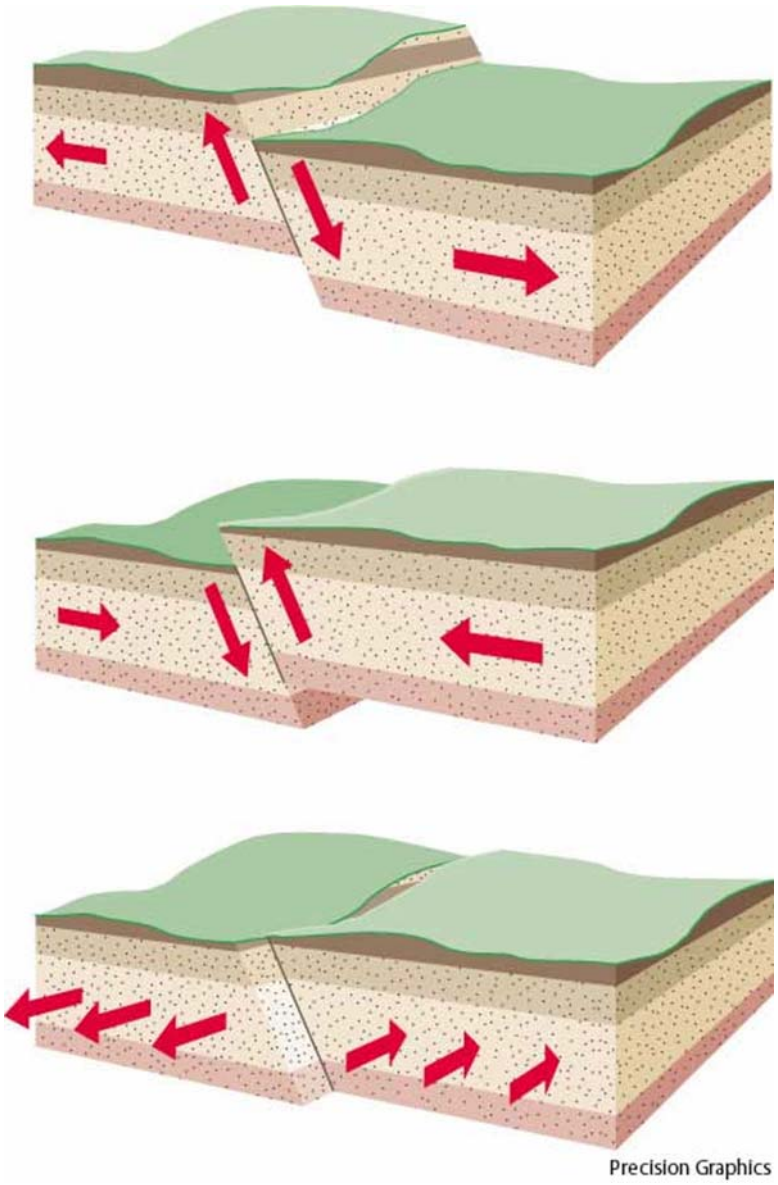


1 As the Pacific Plate and North American Plate move past each other in opposite directions…

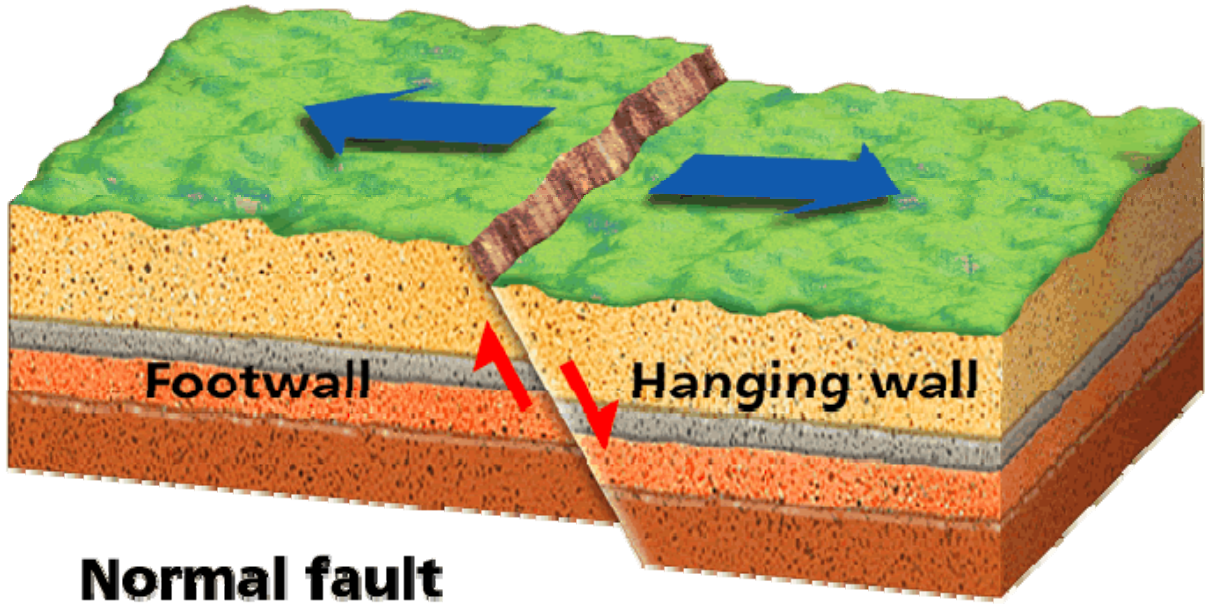
2 …creek beds crossing the fault have been offset.

GEO 435 - Introduction

- A fault is a fracture or zone of fractures between two blocks of rock.
- Faults allow the blocks to move relative to each other. This movement may occur rapidly, in the form of an earthquake - or may occur slowly, in the form of creep.
- Faults may range in length from a few millimeters to thousands of kilometers.
- Most faults produce repeated displacements over geologic time. During an earthquake, the rock on one side of the fault suddenly slips with respect to the other.
- The fault surface can be horizontal or vertical or some arbitrary angle in between.

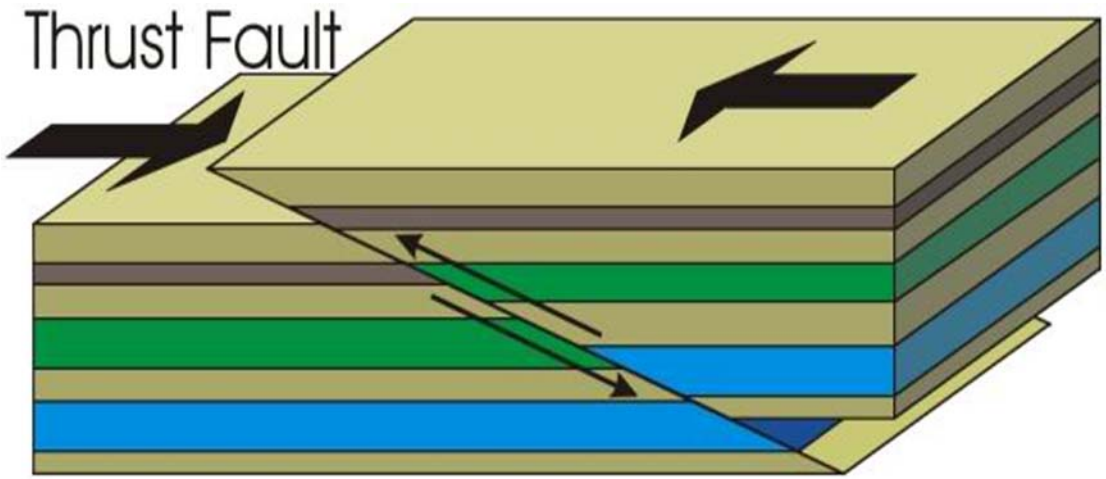


GEO 435 - Introduction

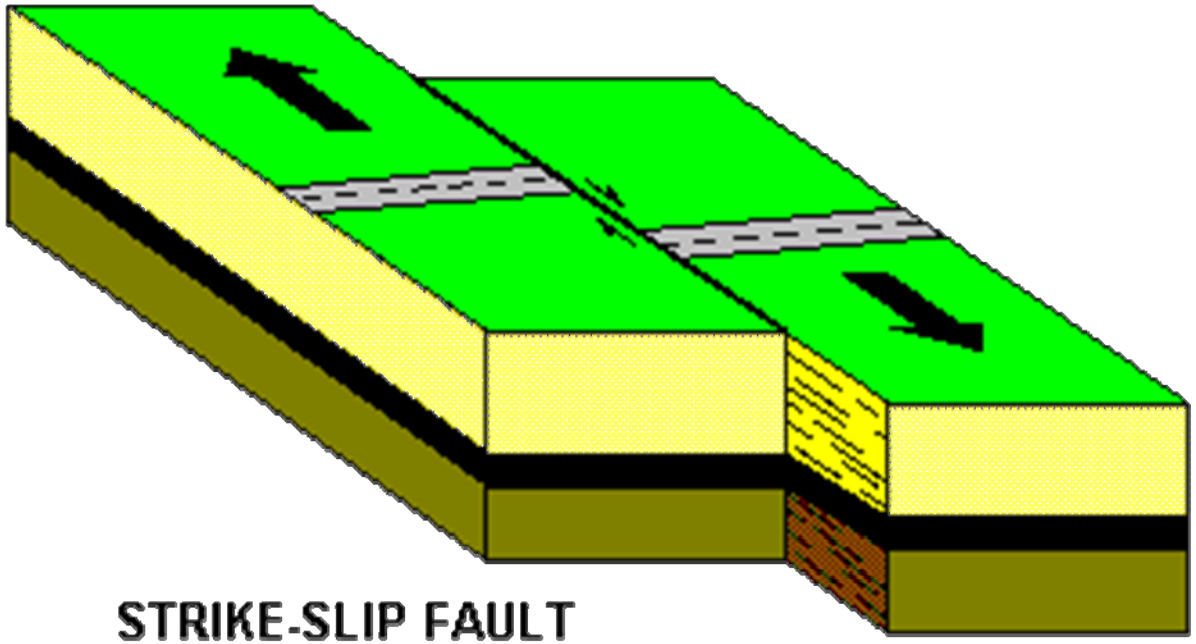


Normal fault
In a normal fault, the hanging wall slips down relative to the footwall.

A normal fault is a dip-slip fault in which the block above the fault has moved downward relative to the block below. This type of faulting occurs in response to extension and is often observed in the Western United States Basin and Range Province and along oceanic ridge systems.

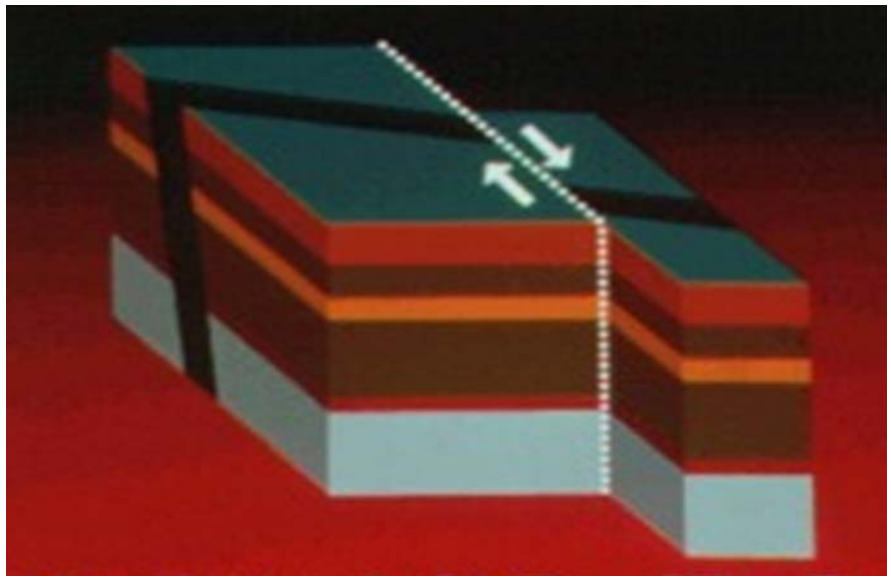


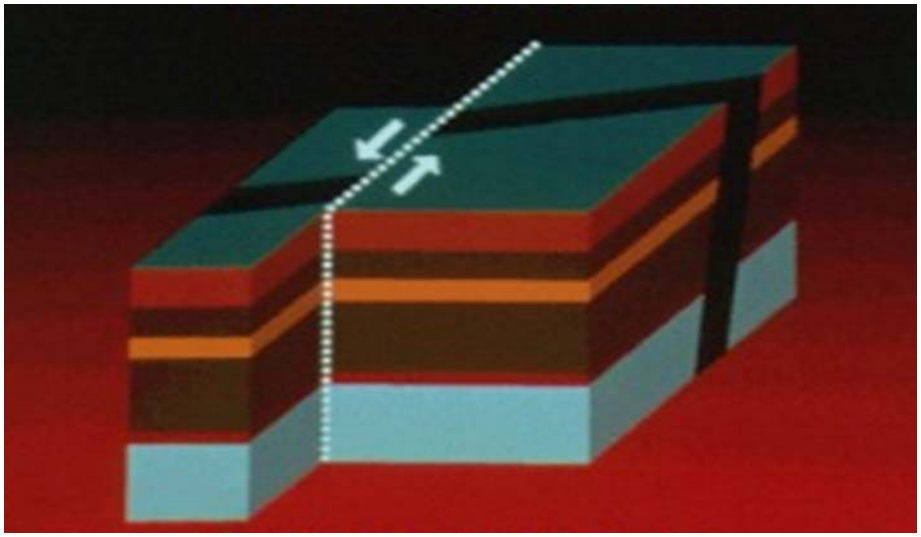
A thrust fault is a dip-slip fault in which the upper block, above the fault plane, moves up and over the lower block. This type of faulting is common in areas of compression, such as regions where one plate is being subducted under another as in Japan and along the Washington coast. When the dip angle is shallow, a reverse fault is often described as a thrust fault.



STRIKE-SLIP FAULT

A strike-slip fault is a fault on which the two blocks slide past one another. These faults are identified as either right-lateral or left lateral depending on whether the displacement of the far block is to the right or the left when viewed from either side. The San Andreas Fault in California is an example of a right lateral fault.

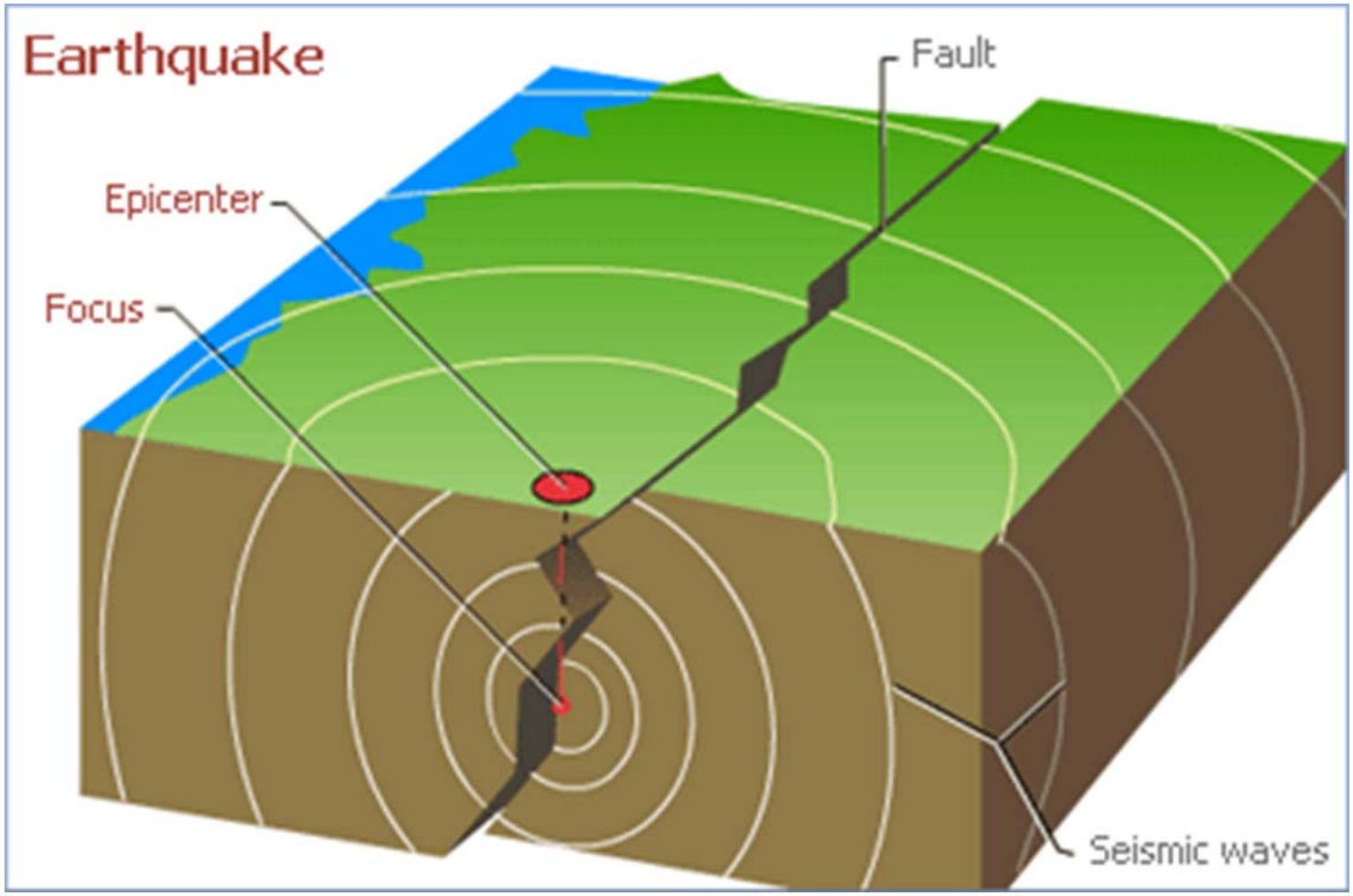




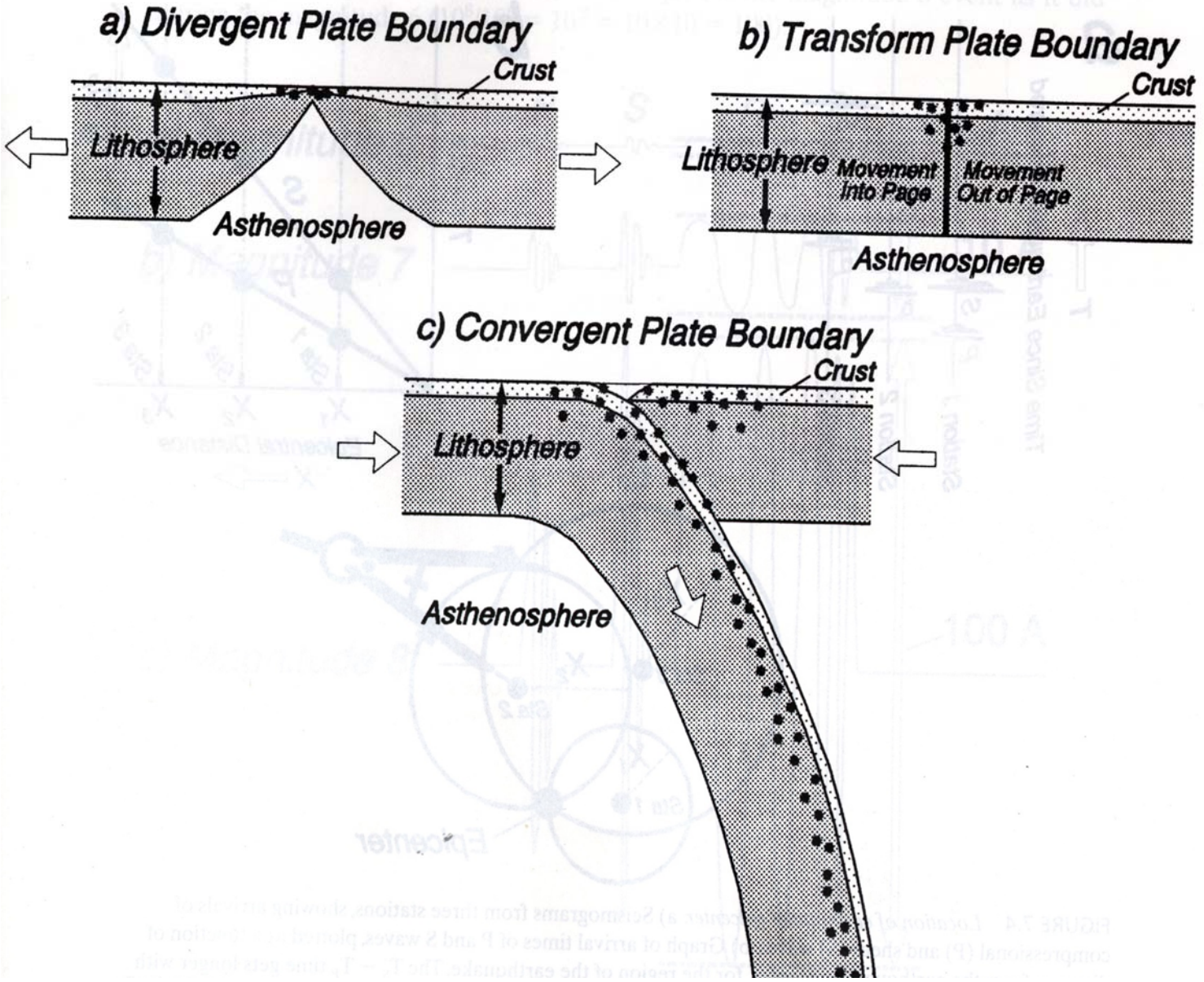
Definitions

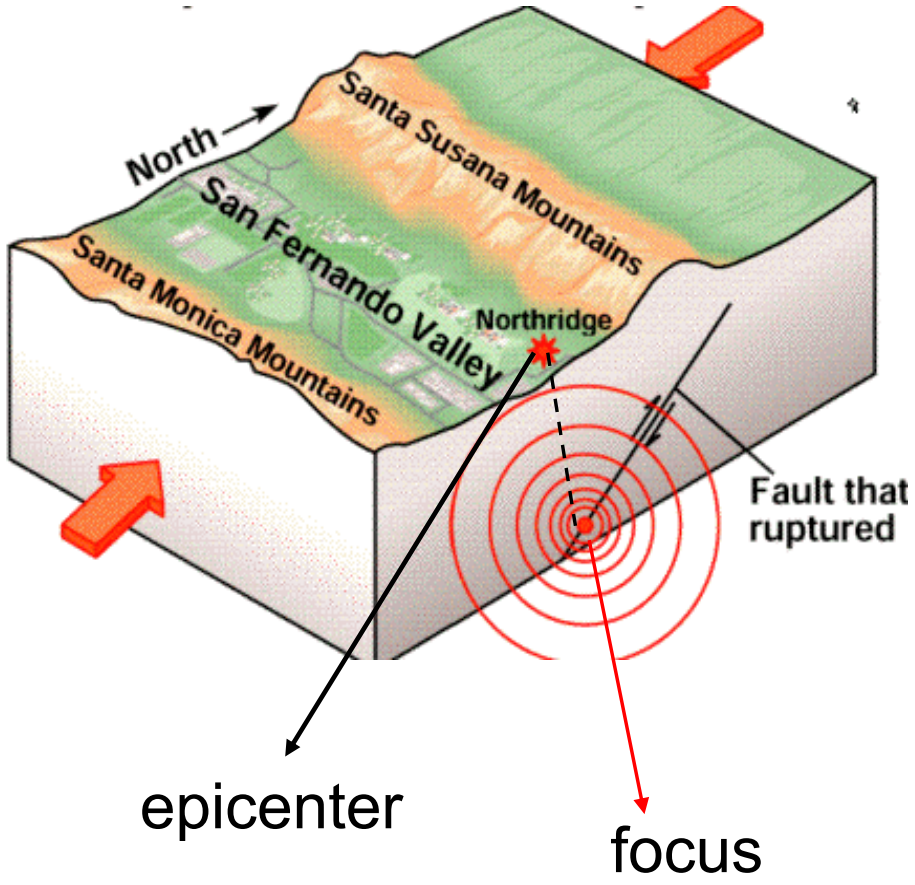
- Earthquake = Vibration of the Earth produced by the rapid release of energy
- Seismic waves = Energy moving outward from the focus of an earthquake
- Focus = location of initial slip on the fault; where the earthquake origins
- Epicenter = spot on Earth's surface directly above the focus

Q. Why do earthquakes occur?


Earthquake
Fault
Epicenter
Focus
Seismic waves

Q. Where do earthquakes occur?


a) Divergent Plate Boundary
Crust
Lithosphere
Asthenosphere
b) Transform Plate Boundary
Crust
Lithosphere
Movement Into Page
Movement Out of Page
Asthenosphere
c) Convergent Plate Boundary
Crust
Lithosphere
Asthenosphere



- *Fractures, faults*
- Energy released

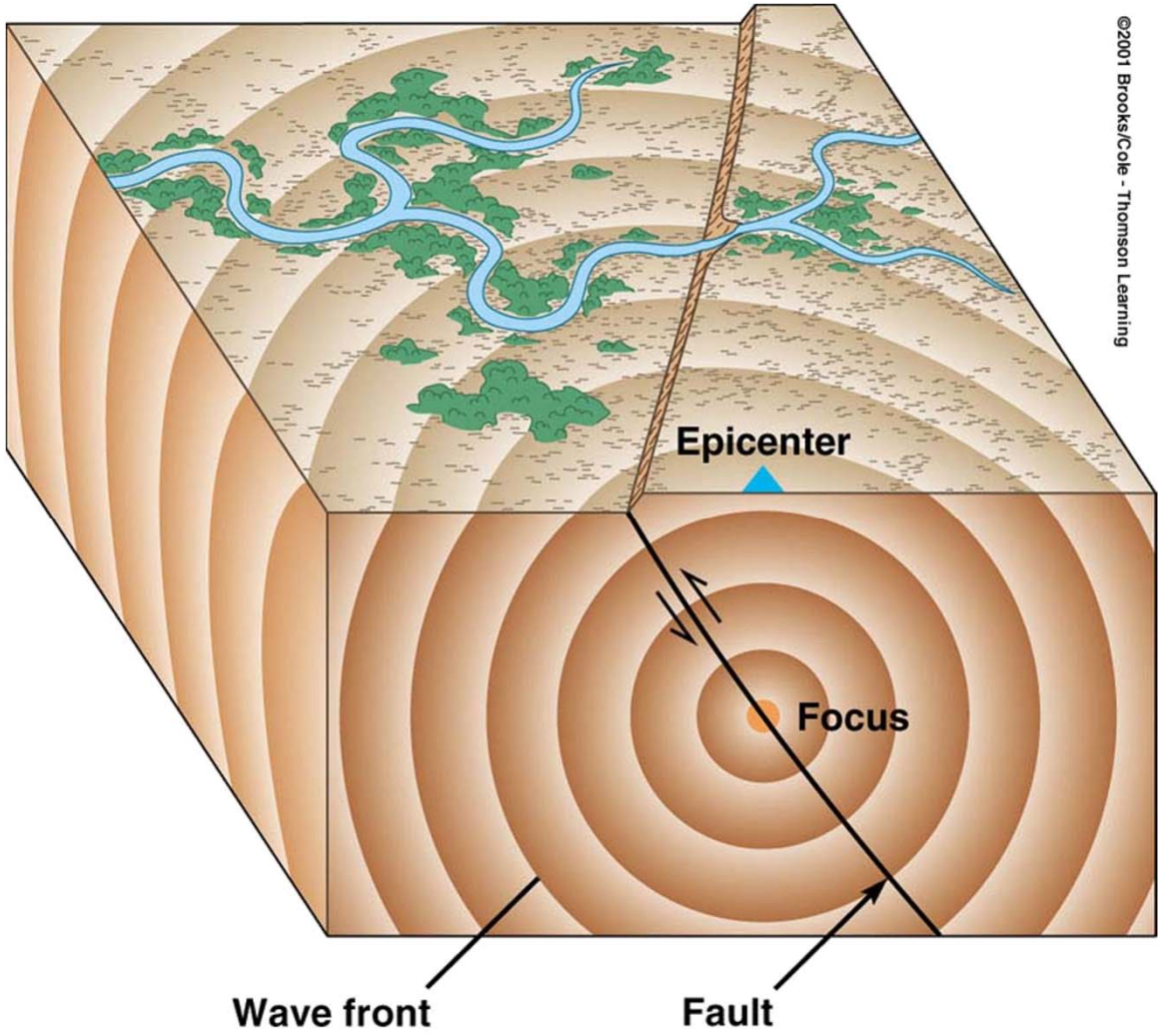
and propagates in all directions as seismic waves causing earthquakes.

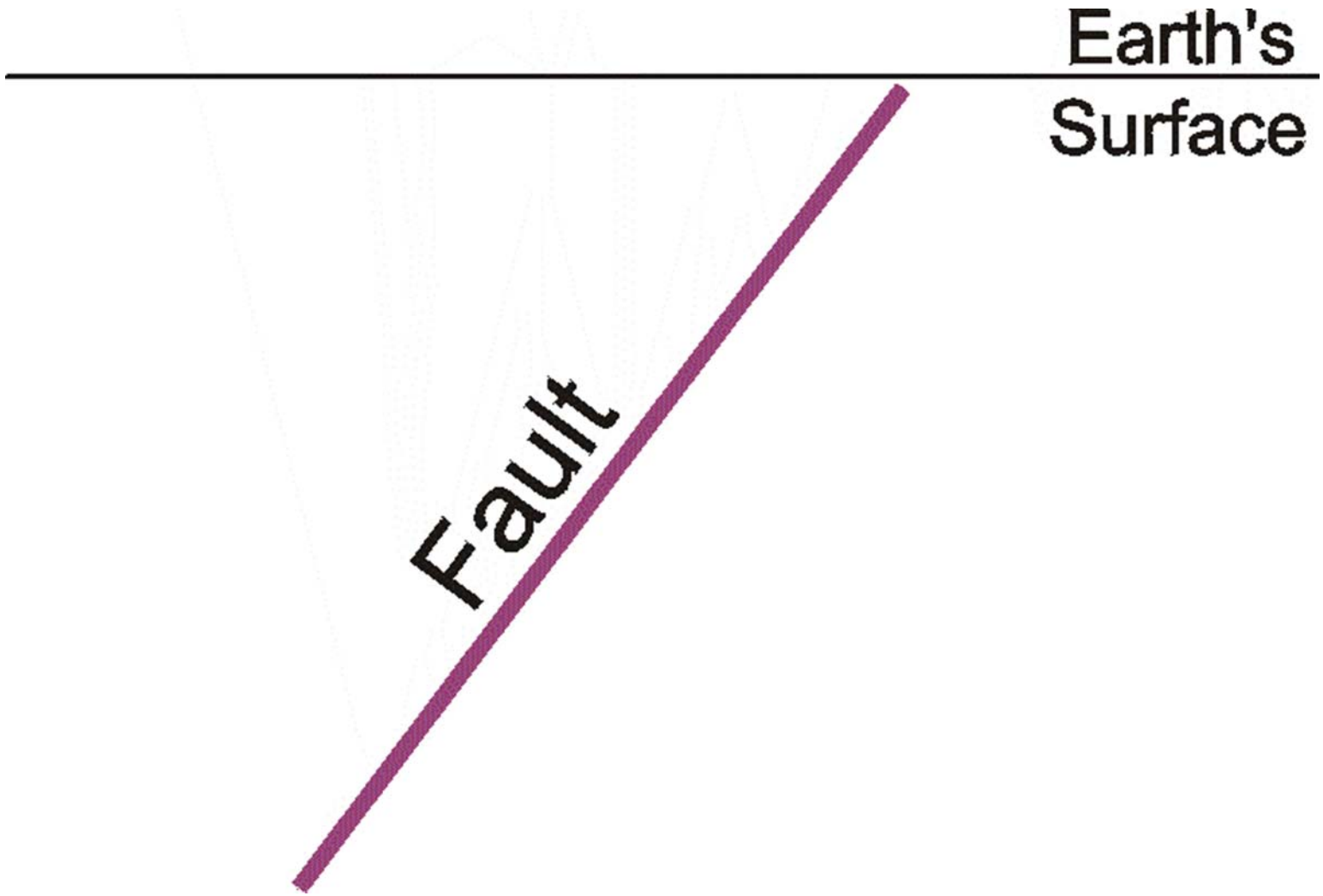
Focus

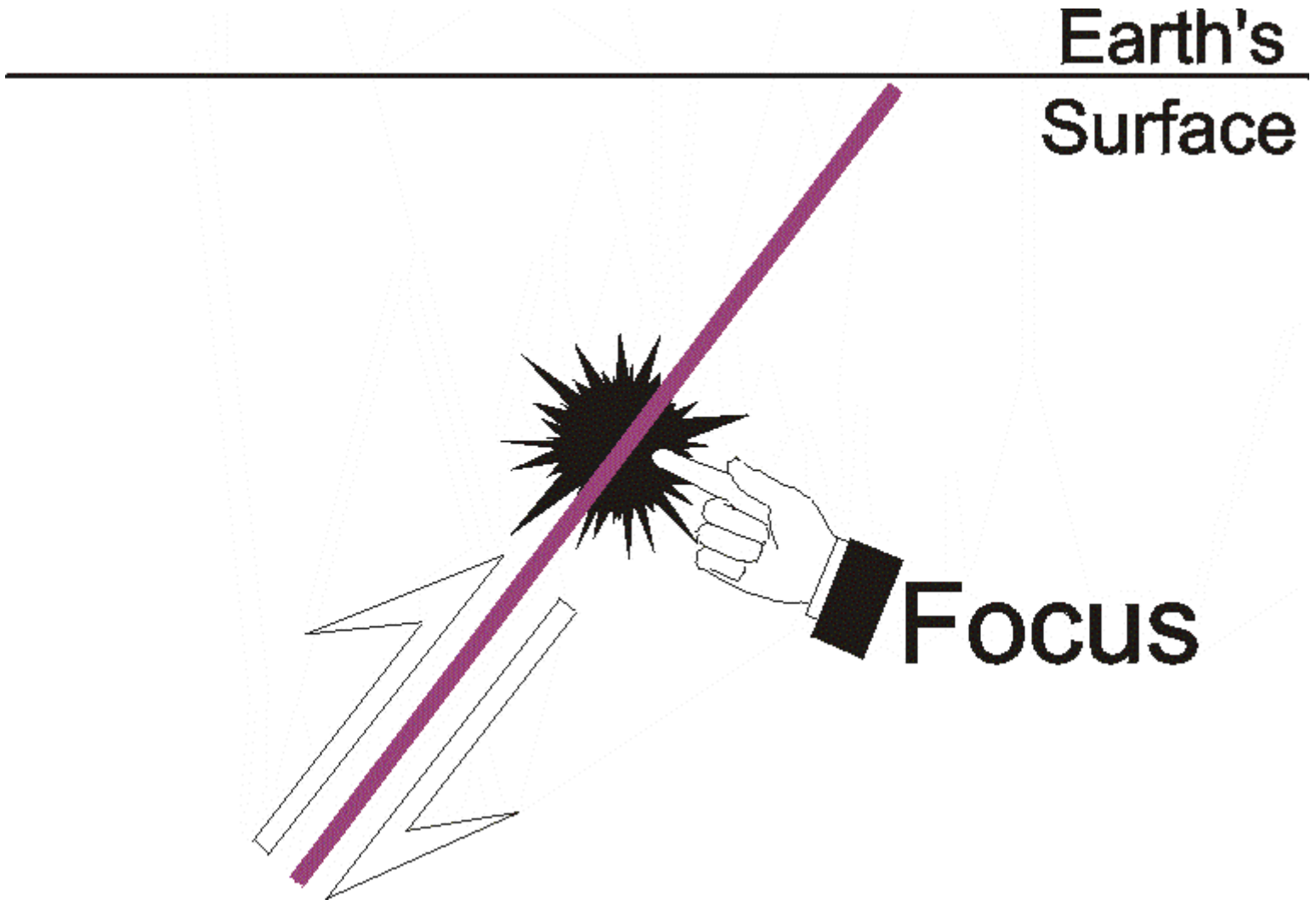
Actual point of rupture within the Earth.

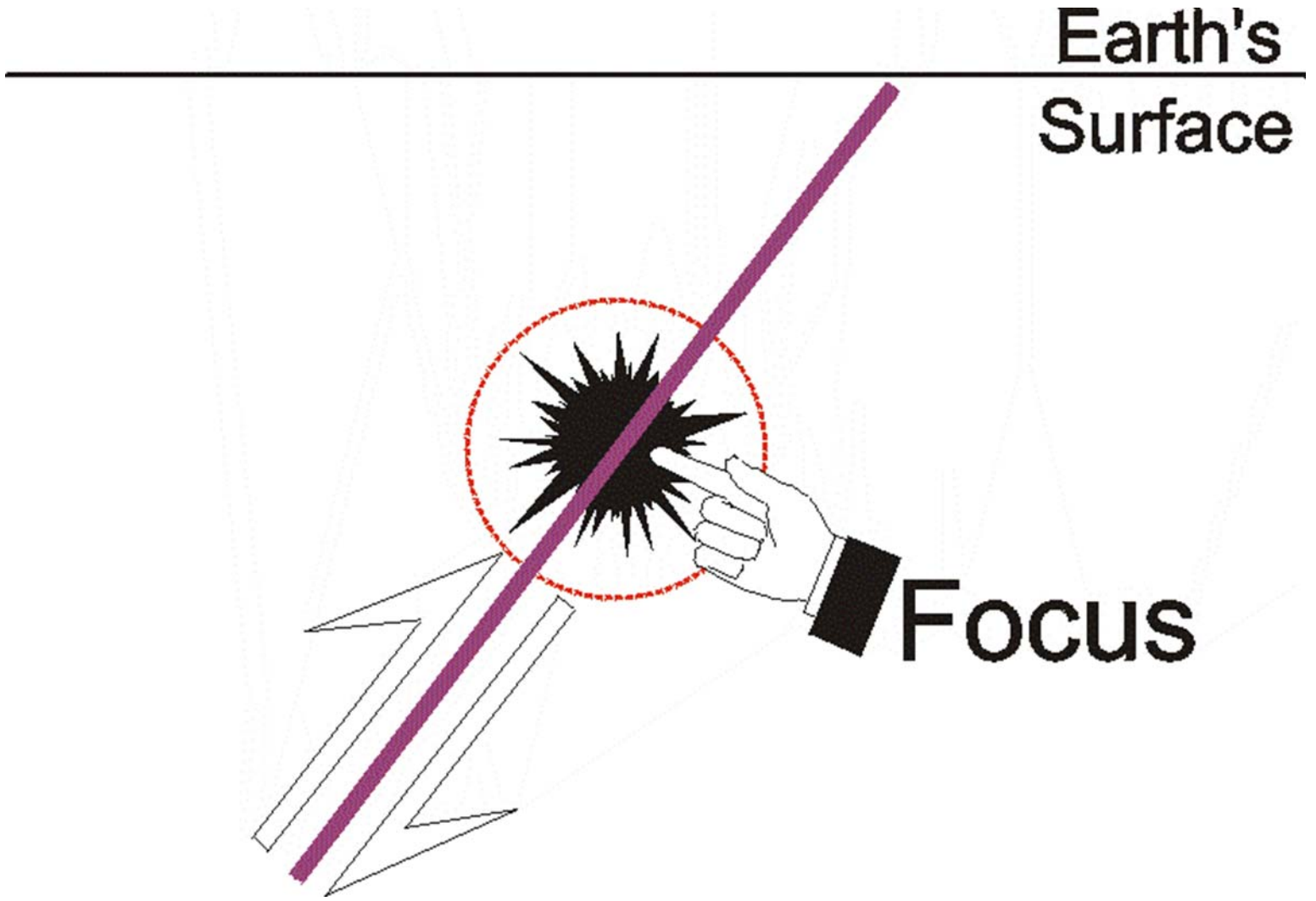
Epicenter

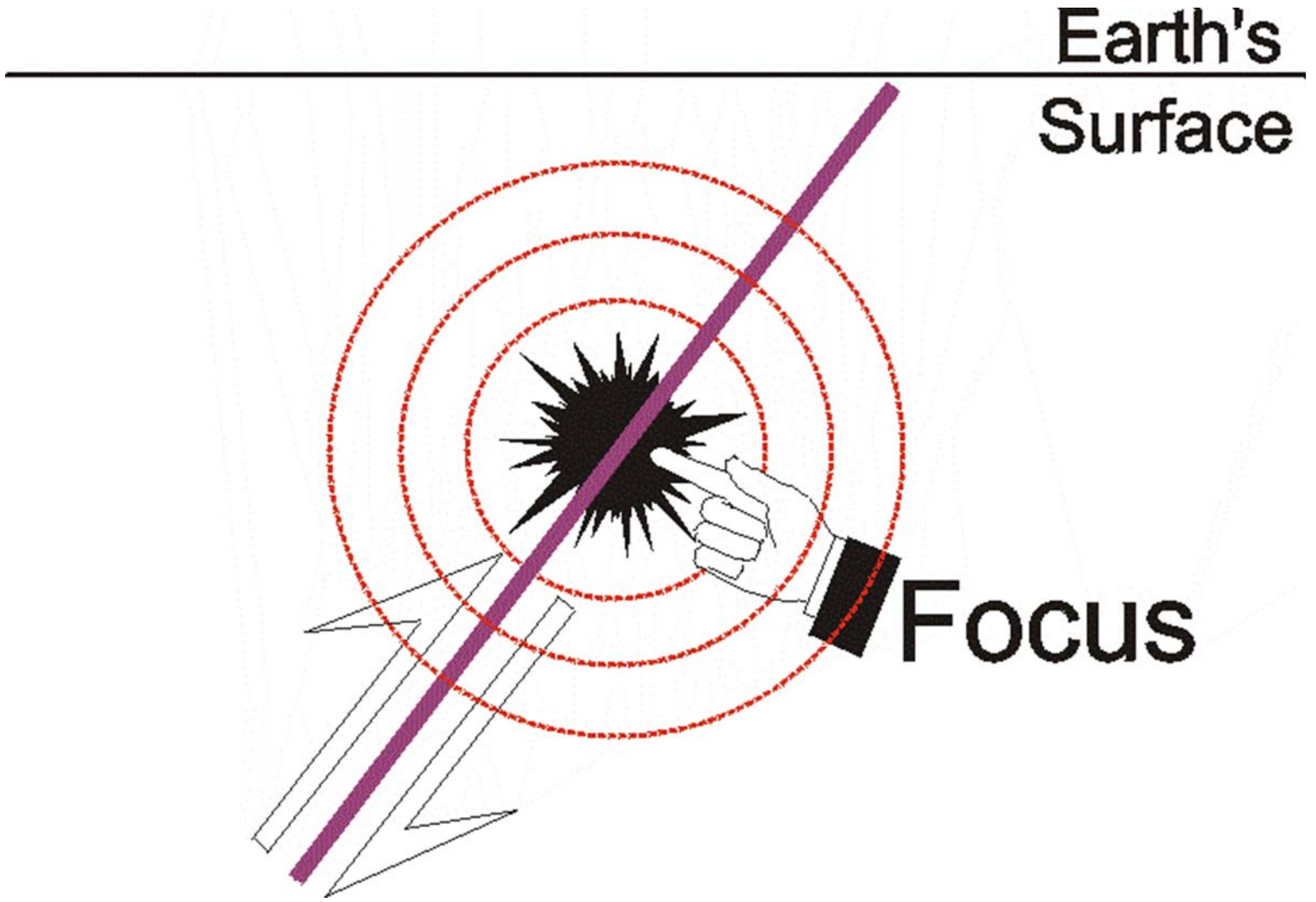
Point on Earth's surface directly above the focus.

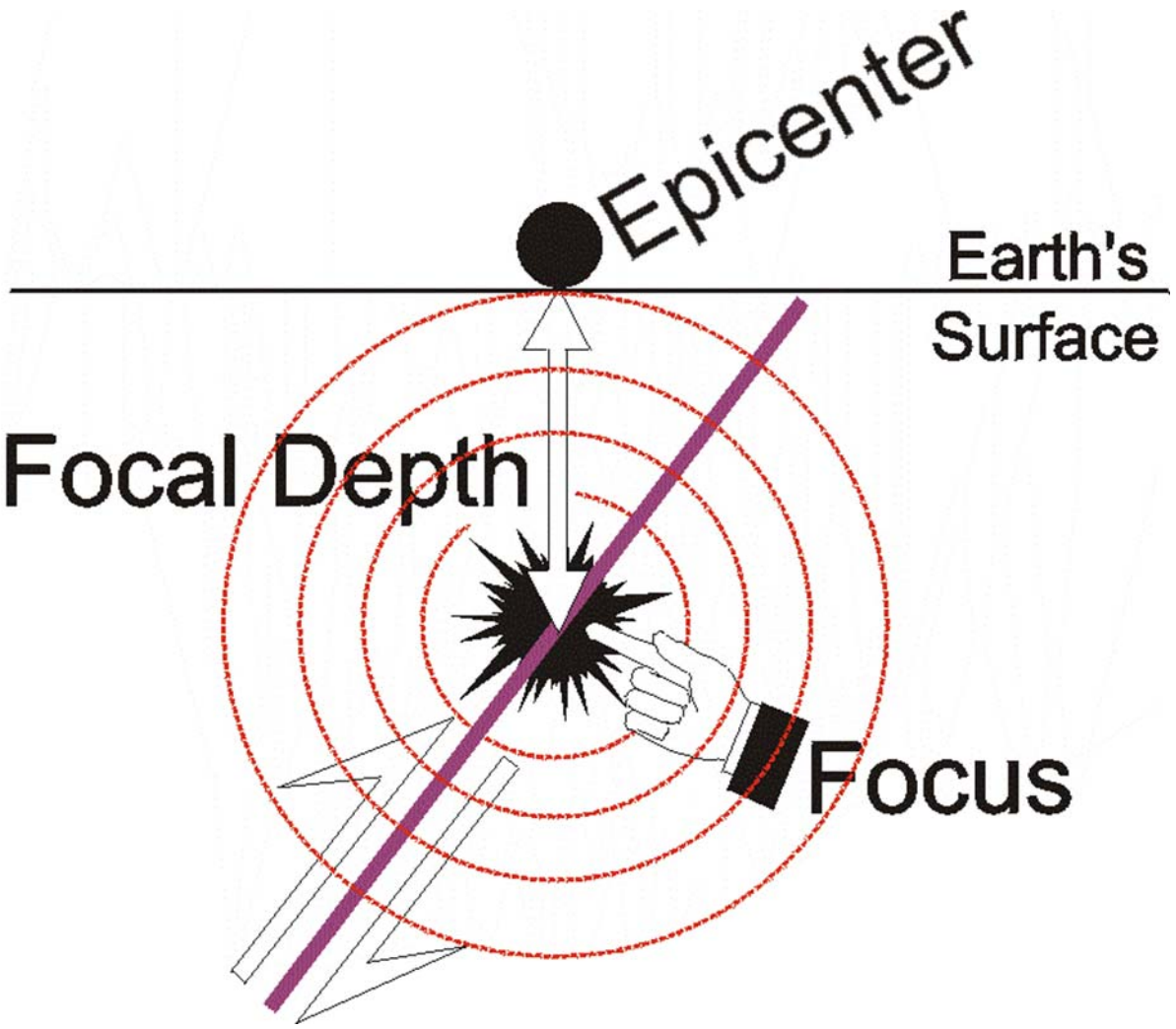

©2001 Brooks/Cole - Thomson Learning
Epicenter
Focus
Wave front
Fault

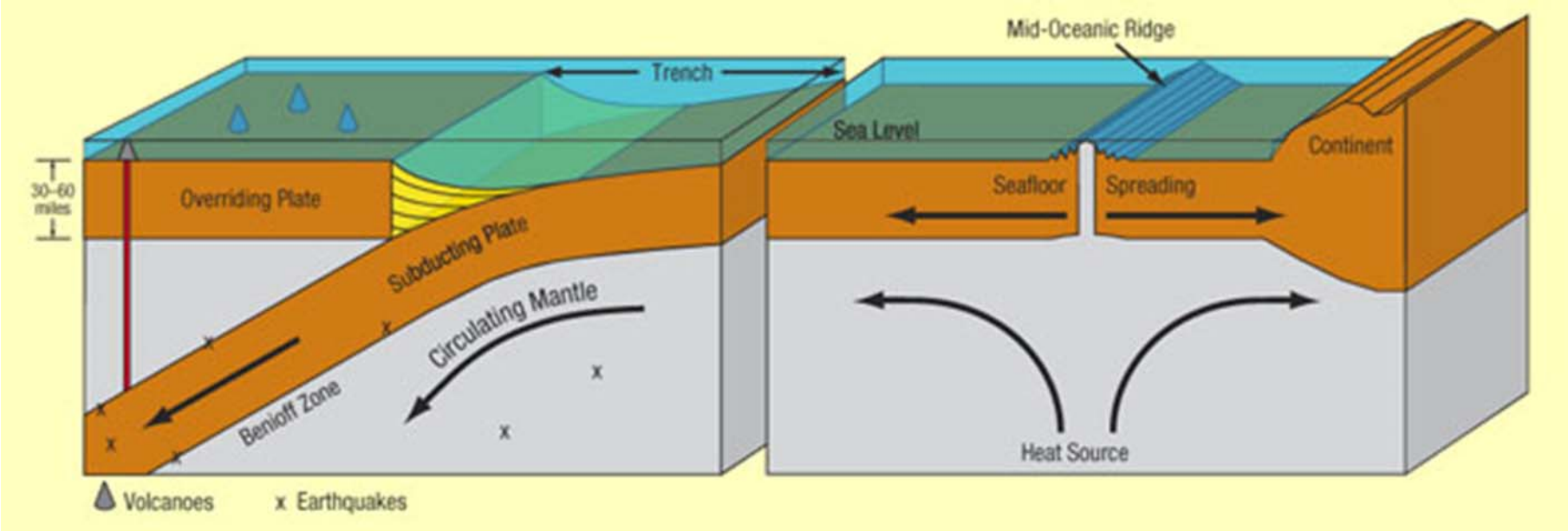

Earth's
Surface
Fault

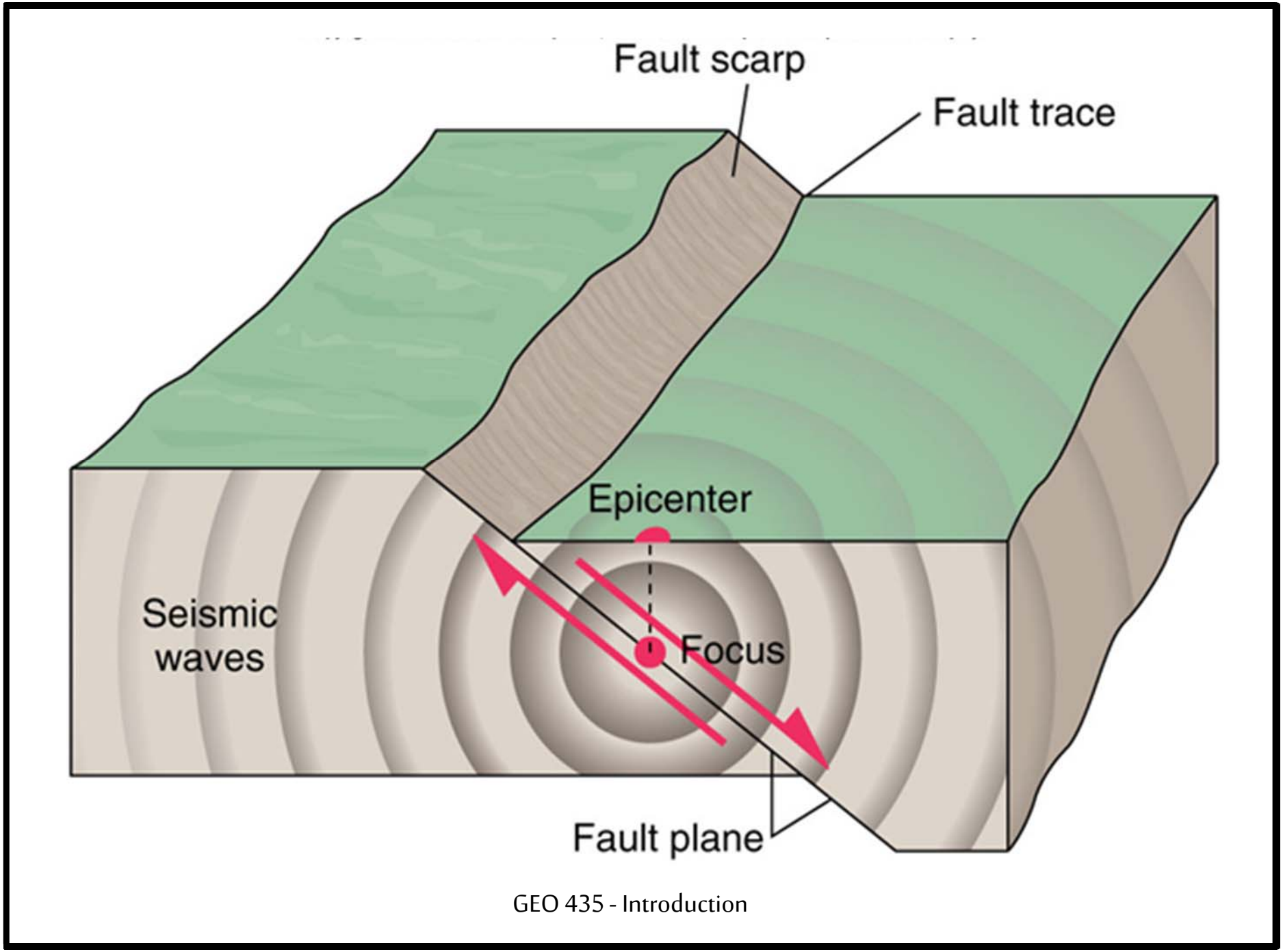

Earth's
Surface
Focus


Earth's
Surface
Focus


Earth's
Surface
Focus


Epicenter
Earth's
Surface
Focal Depth
Focus


Mid-Oceanic Ridge
Trench
Sea Level
Continent
30–60 miles
Overriding Plate
Seafloor
Spreading
Subducting Plate
Circulating Mantle
Benioff Zone
Heat Source
Volcanoes
Earthquakes


Fault scarp
Fault trace
Epicenter
Seismic
waves
Focus
Fault plane

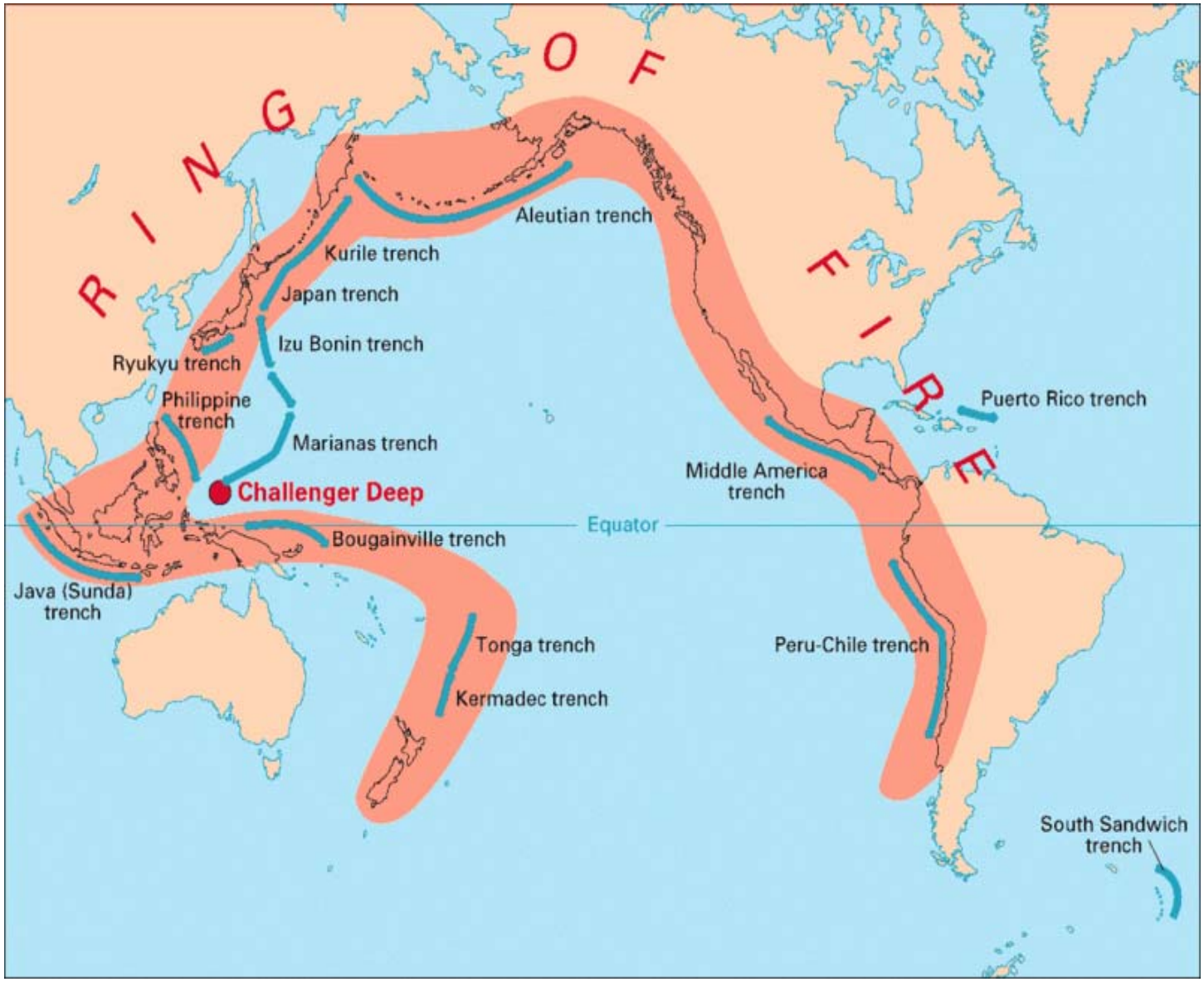
Types of earthquakes

There are many different types of earthquakes: tectonic, volcanic, and explosion. The type of earthquake depends on the region where it occurs and the geological make-up of that region.

1. **Tectonic earthquakes.** These occur when rocks in the earth's crust break due to geological forces created by movement of tectonic plates.
2. **Volcanic earthquakes** occur in conjunction with volcanic activity.
3. **Collapse earthquakes** are small earthquakes in underground caverns and mines.
4. **Explosion earthquakes** result from the explosion of nuclear and chemical devices.

Q. Earthquakes, why and where do they occur?

- It has long been recognized that earthquakes are not evenly distributed over the earth.
- The eventual correlation of the earthquake pattern with the earth's major surface features was a key to the evolution of the plate tectonics theory.
- The basic idea is that the earth's outermost part (Lithosphere) consists of several large and fairly stable slabs of solid and relatively rigid rock called plates.


RING OF FIRE
Aleutian trench
Kurile trench
Japan trench
Izu Bonin trench
Ryukyu trench
Philippine trench
Marianas trench
Challenger Deep
Bougainville trench
Java (Sunda) trench
Tonga trench
Kermadec trench
Equator
Middle America trench
Puerto Rico trench
Peru-Chile trench
South Sandwich trench