Geology – Brad Paisley 5/10/2014

Midterm #2 Info

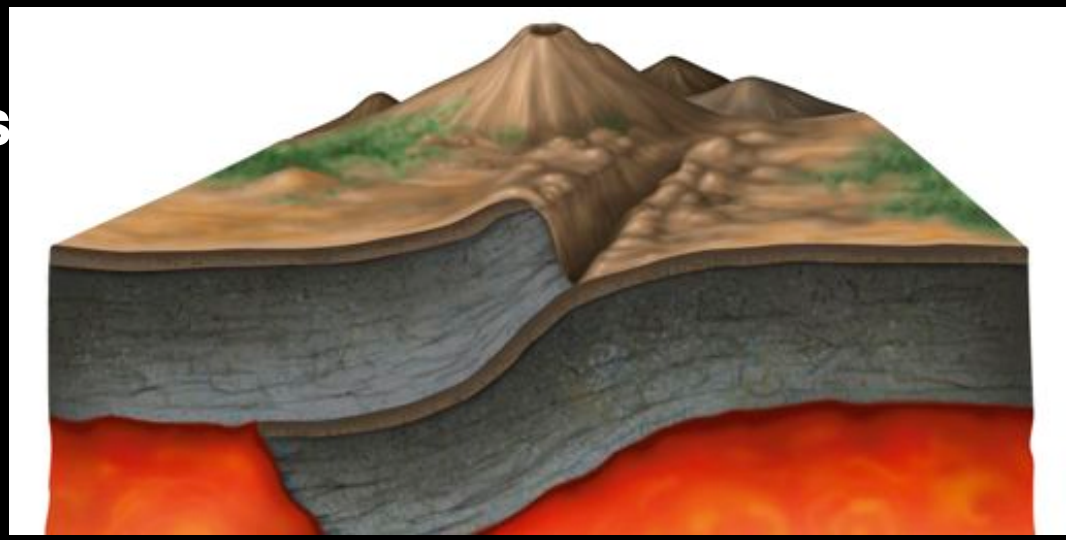
- Midterm info:
  - Midterm exam on Thursday, October 29th
  - 50 multiple choice/true-false questions
  - Covers material from Lectures 9-17
  - 1 hand-written page "cheat sheet" allowed (double-sided ok)
  - Things to help you study:
    1. Lecture notes
    2. Midterm practice exam (posted on web)
    3. Homework
    4. Assigned reading

Class Website

http://www.soest.hawaii.edu/GG/FACULTY/smithkonter/GG_101/

Learning Objectives (LO)

Lecture 10: Plate Tectonics
Chapter 3



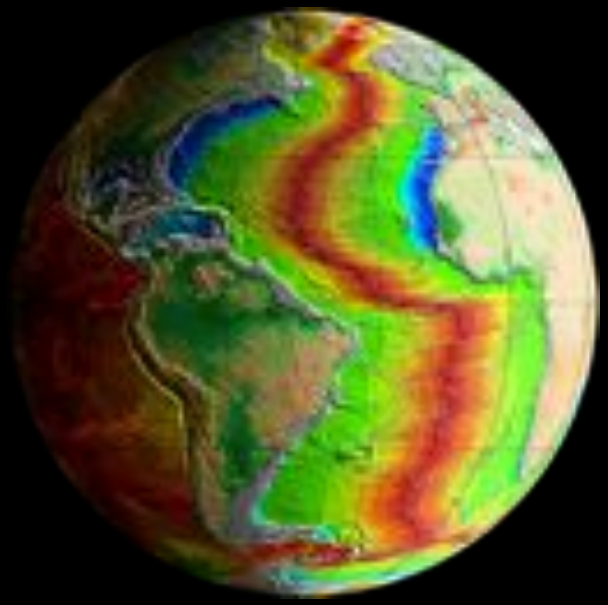
1. Describe the origin and recycling of oceanic crust
2. Identify the evidence that the polarity of Earth's geomagnetic field has reversed in the past
3. Describe the additional evidence that supports the theory of plate tectonics

iClicker Question

Which of these do you think provide evidence of plate tectonics?

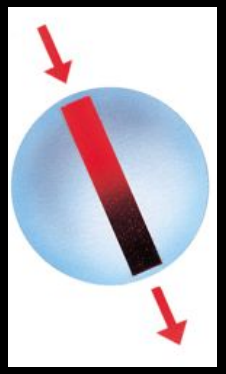
1. A reversing, symmetric pattern of Earth's magnetic field (recorded in rocks)
2. Large mountain chains found on the bottom of the ocean floor
3. Rock ages that are young at ocean ridges and old at distances far from ridges
4. High heat flow identified at ocean ridges and low heat far from ridges

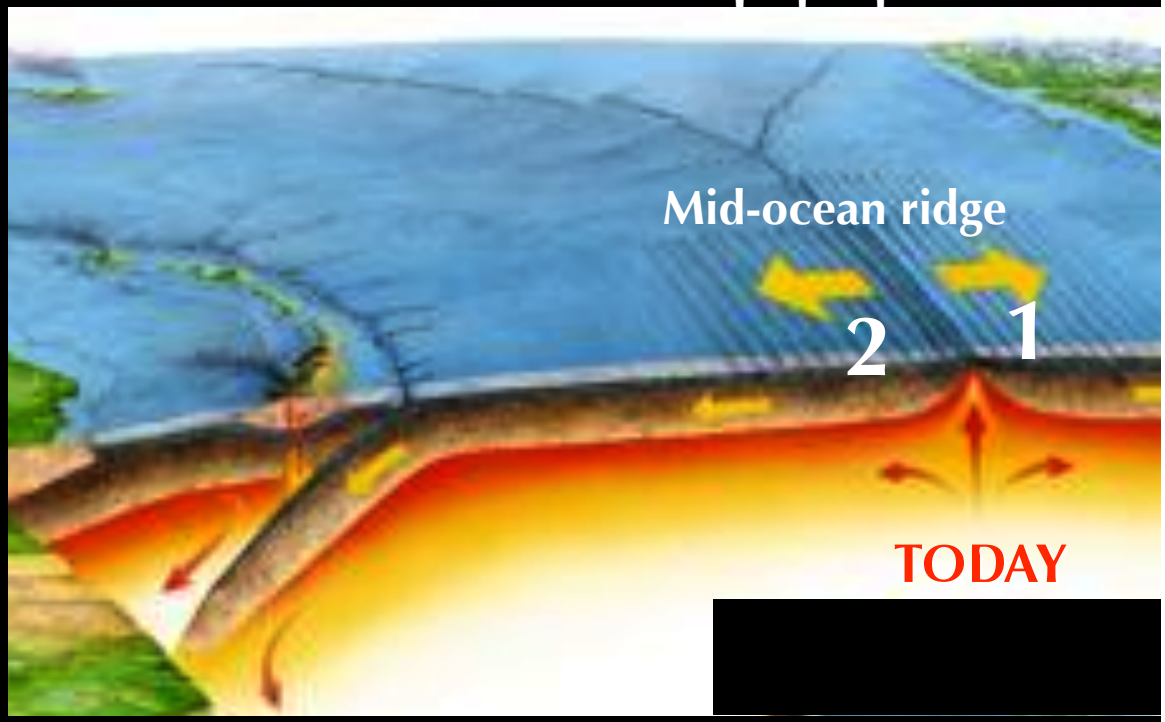
A. 1, 3, 5
B. 1, 2, 5
C. 1, 4, 5
D. All



iClicker Question

How are rocks magnetized at the junction of locations 1 & 2?



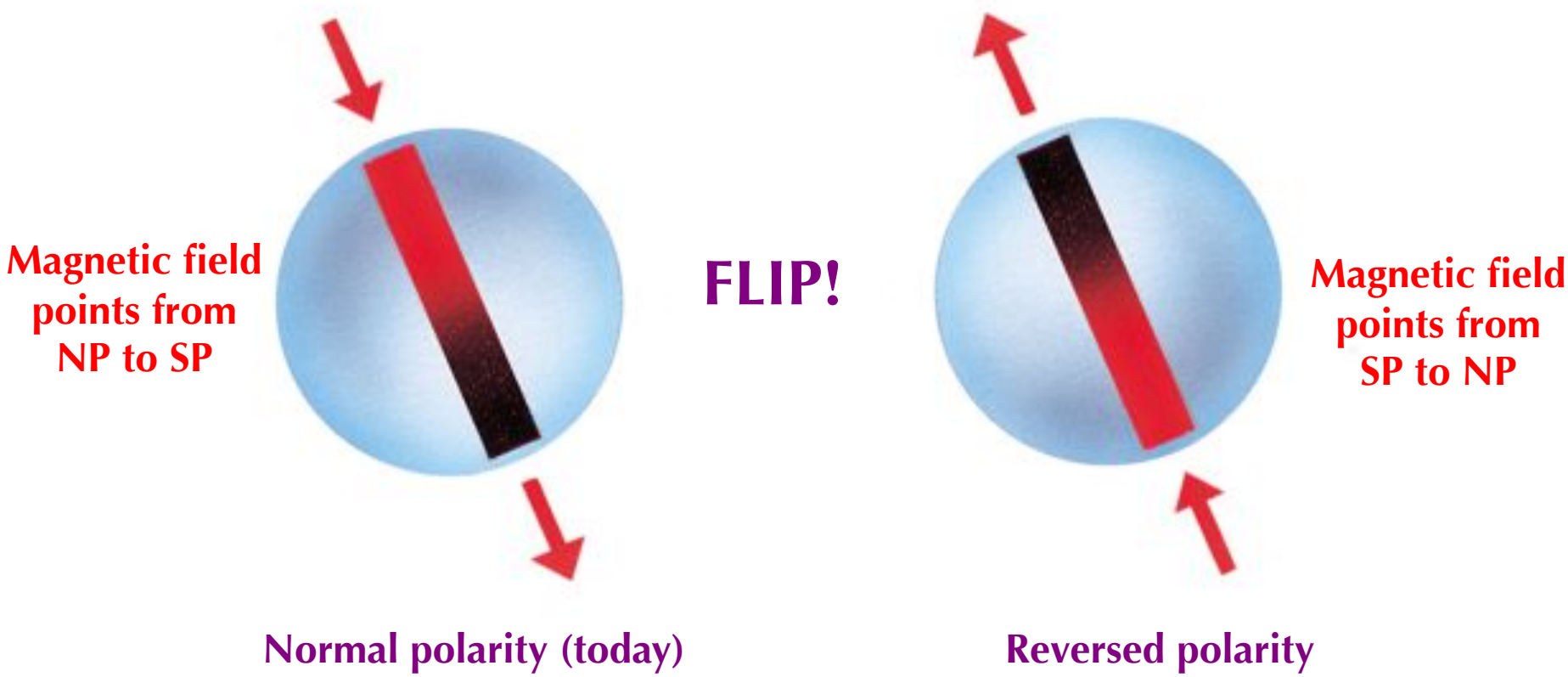


a. Hot lava emerges at the surface, registers normal polarity
b. Hot lava emerges at the surface, registers reverse polarity
c. Hot lava sinks into the mantle, registers reverse polarity
d. Hot lava sinks into the mantle, registers normal polarity

Reversals of the Magnetic Field

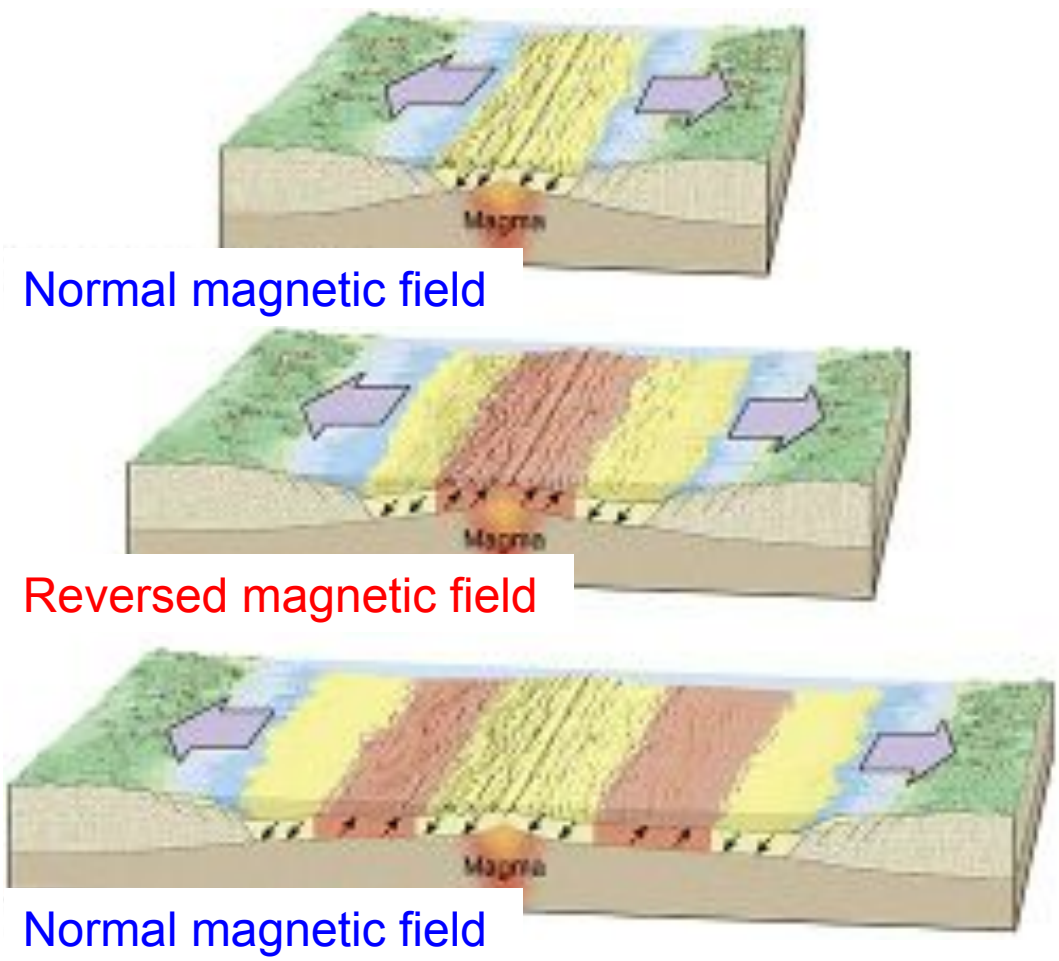
- Earth's magnetic field can be represented by a **dipole** that points from the north magnetic pole to the south

- Every now and then, the magnetic polarity **reverses**



Seafloor Magnetic Reversals

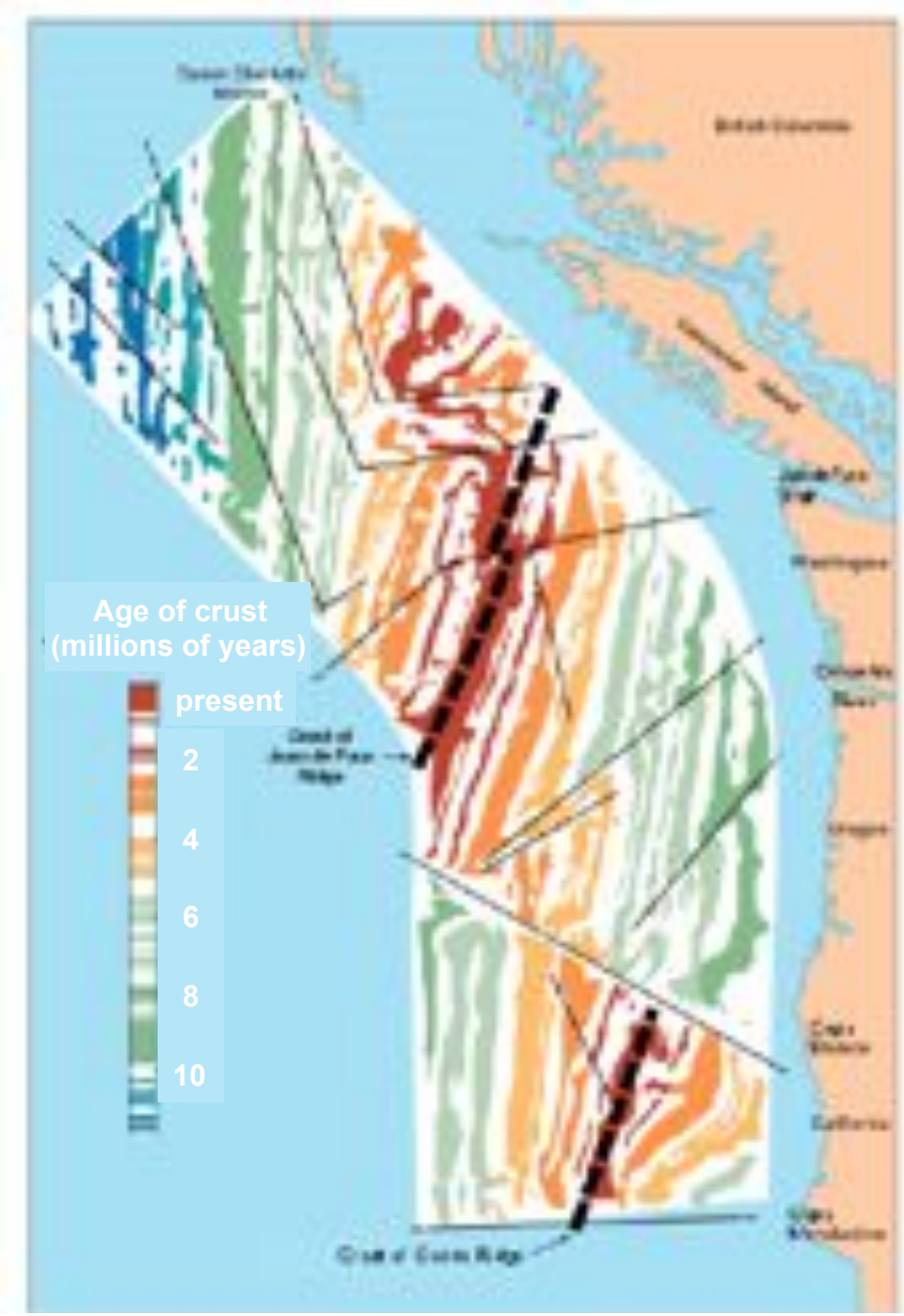
- Oceanic crust preserves a record of Earth's magnetic polarity at the time the crust formed



New seafloor is being created as the seafloor spreads.

The continents move apart as new seafloor expands the ocean basin

The magnetic field is "frozen" in the newly-created seafloor.



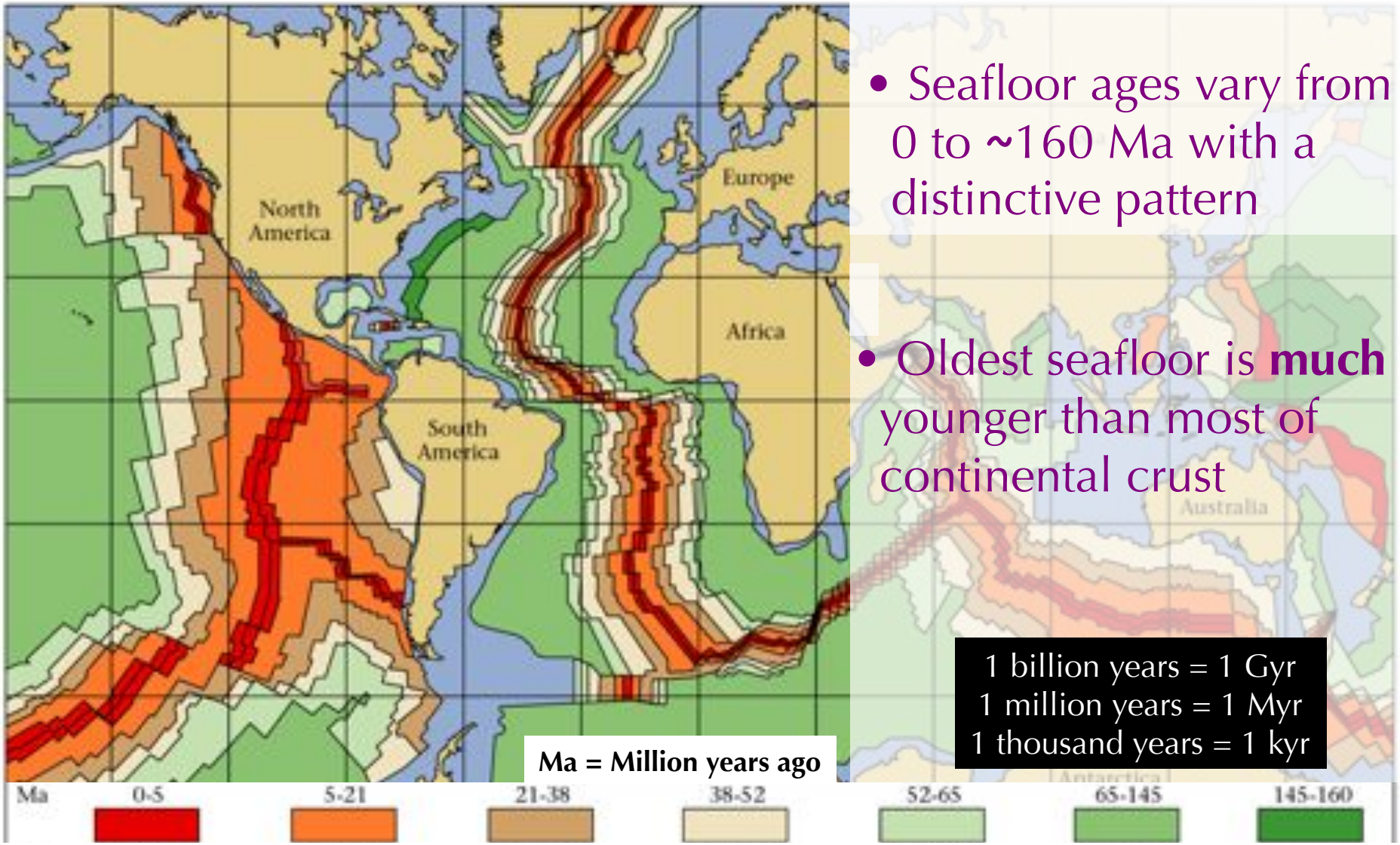
"Stripes" & Seafloor Age

- The pattern of magnetic "stripes" discovered all over ocean floor

- **Found:** increasing seafloor age away from ridge center

  - young rocks ⟶ nearby
  - old rocks ⟶ far away

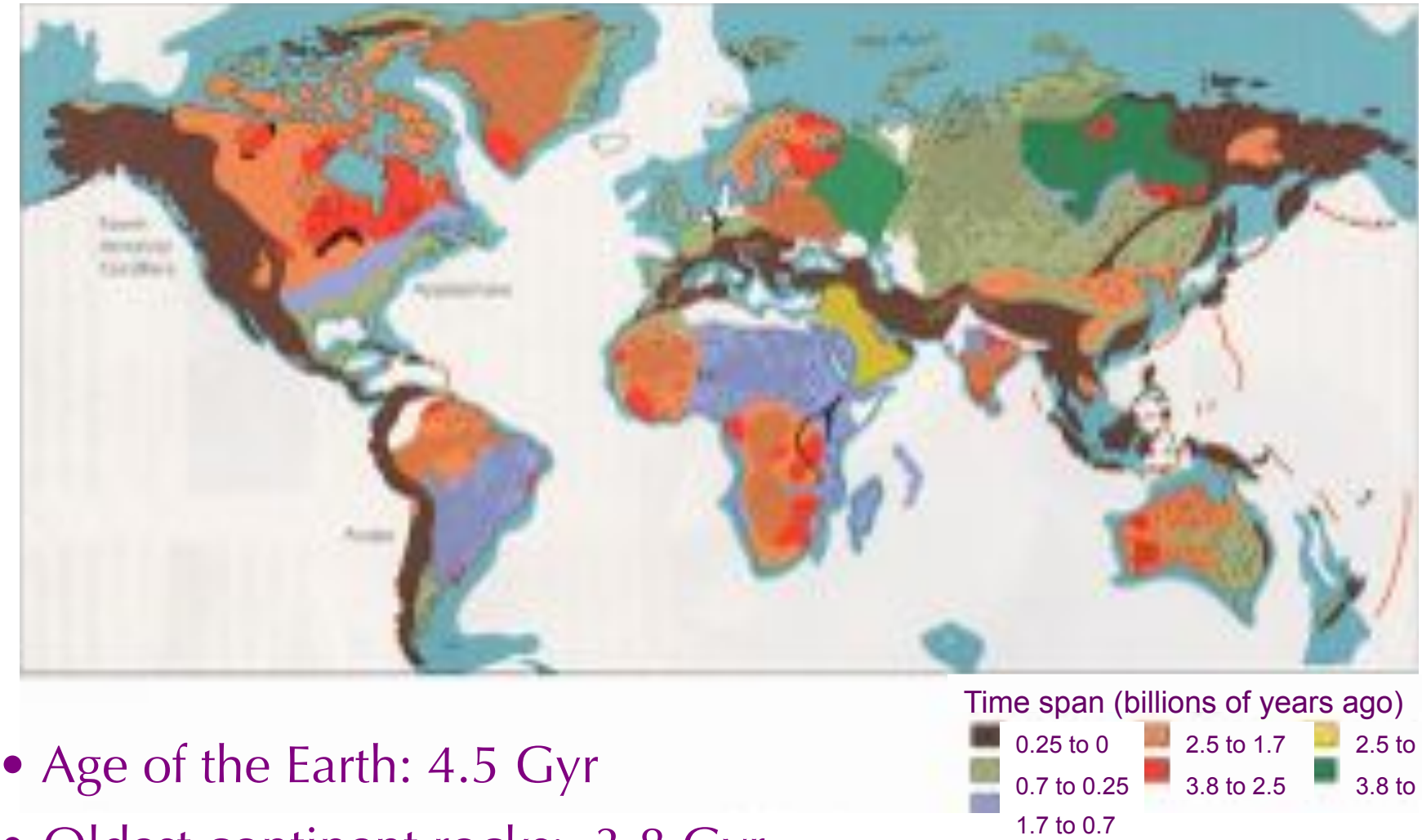
Ages of the Ocean Floor



- Seafloor ages vary from 0 to ~160 Ma with a distinctive pattern
- Oldest seafloor is **much** younger than most of continental crust

1 billion years = 1 Gyr
1 million years = 1 Myr
1 thousand years = 1 kyr

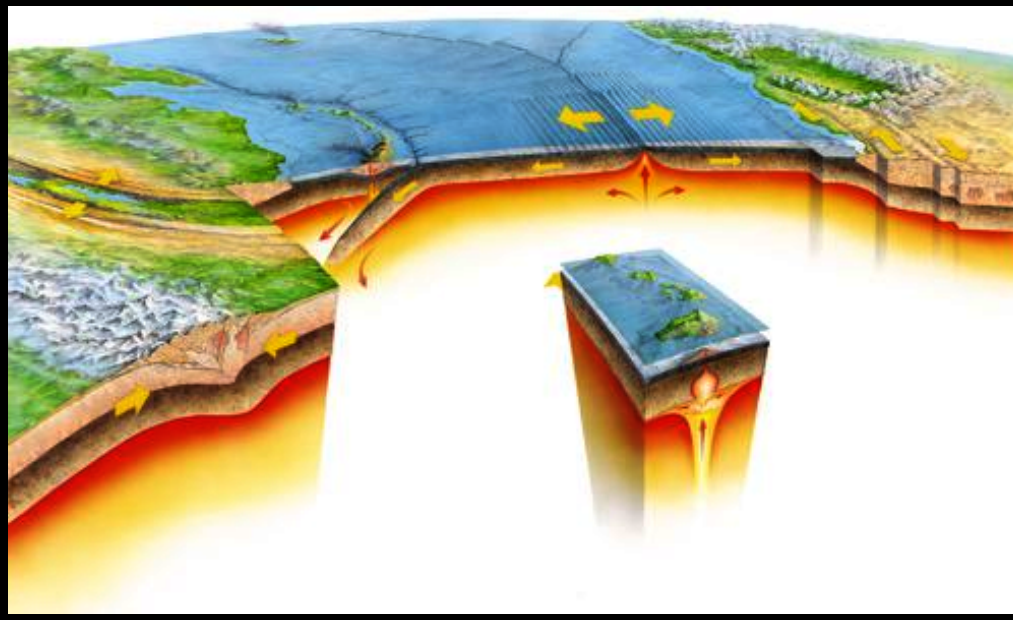
Ages of Continental Rocks



- Age of the Earth: 4.5 Gyr
- Oldest continent rocks: 3.8 Gyr
- Youngest continent rocks: 250 Myr

Learning Objectives (LO)

Lecture 11: Plate Tectonics II
Chapter 3

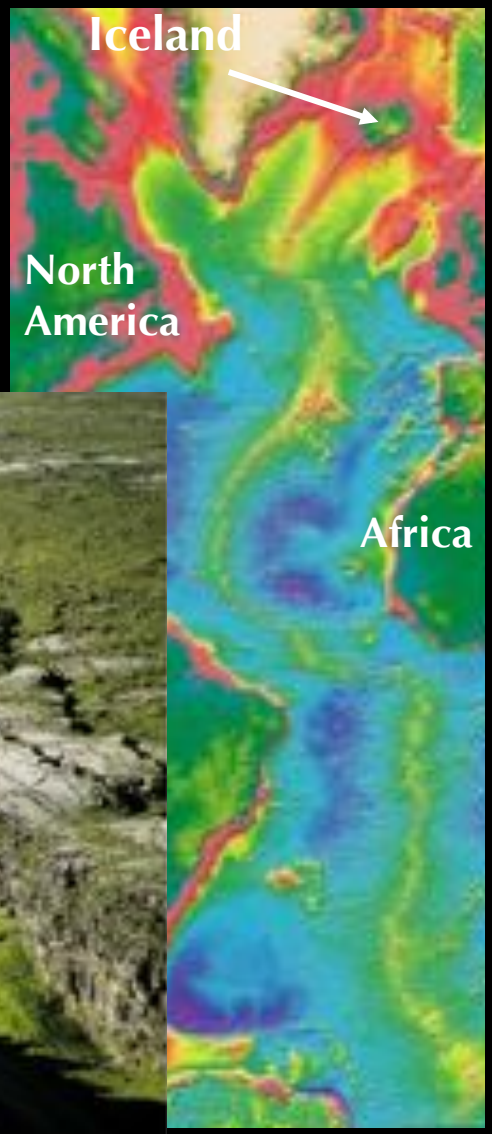


1. List the three types of tectonic plate boundaries
2. Describe the processes occurring at ocean-continent and ocean-ocean convergent boundaries
3. Describe the origin of the Himalayas
4. Describe the San Andreas transform fault

iClicker Question

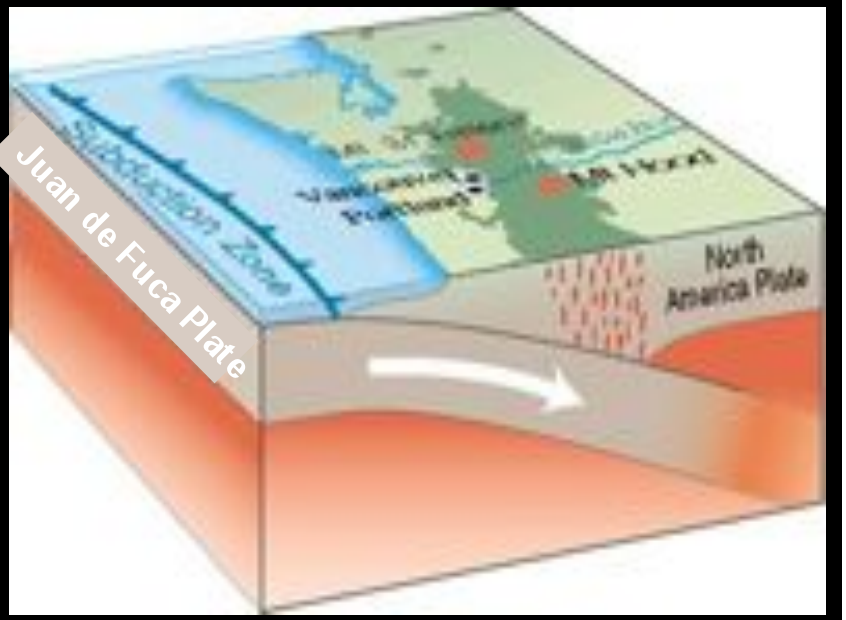
Iceland lies in the middle of the Atlantic Ocean and is tectonically active. What type of plate boundary is Iceland?

a. Subduction Zone
b. Spreading Center
c. Transform Fault



iClicker Question

The Pacific Northwest is a tectonically active region due to the interaction of the North American Plate and a smaller plate known as the Juan de Fuca Plate. Which of the following is true of the region?



a. Formed by spreading, possible volcanoes, big earthquakes & tsunamis

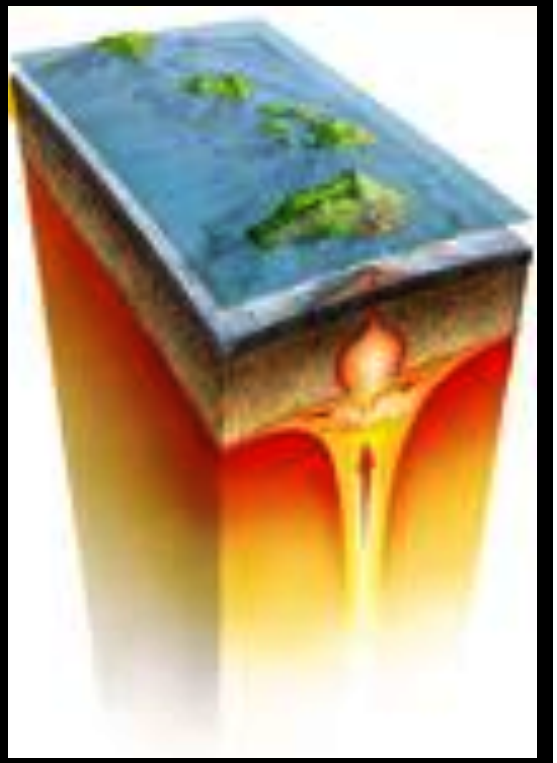
b. Formed by spreading, possible volcanoes & small earthquakes

c. Formed by subduction, possible volcanoes, big earthquakes & tsunamis

d. Formed by subduction, possible volcanoes & small earthquakes

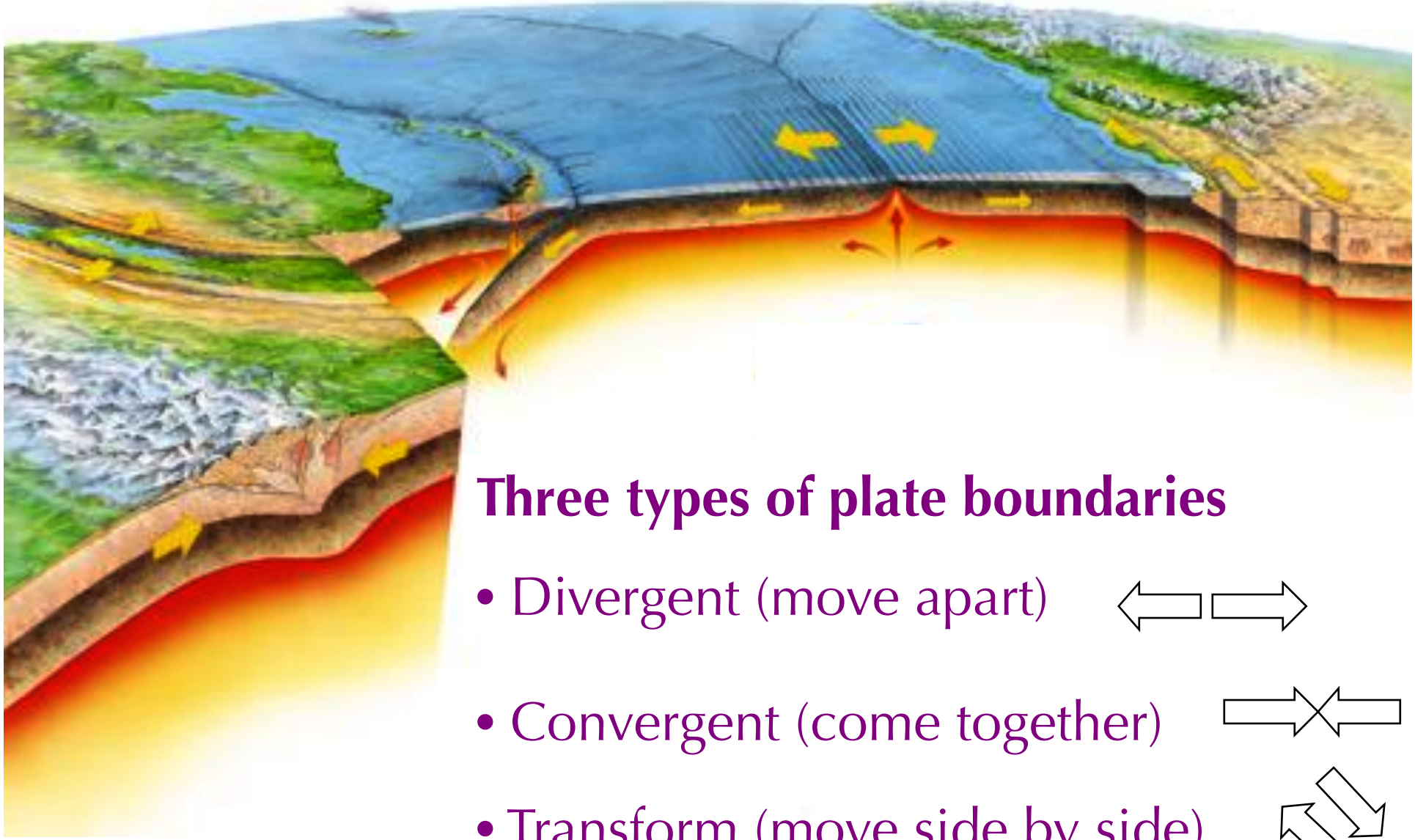
iClicker Question

The Hawaiian Island hotspot chain was formed by:



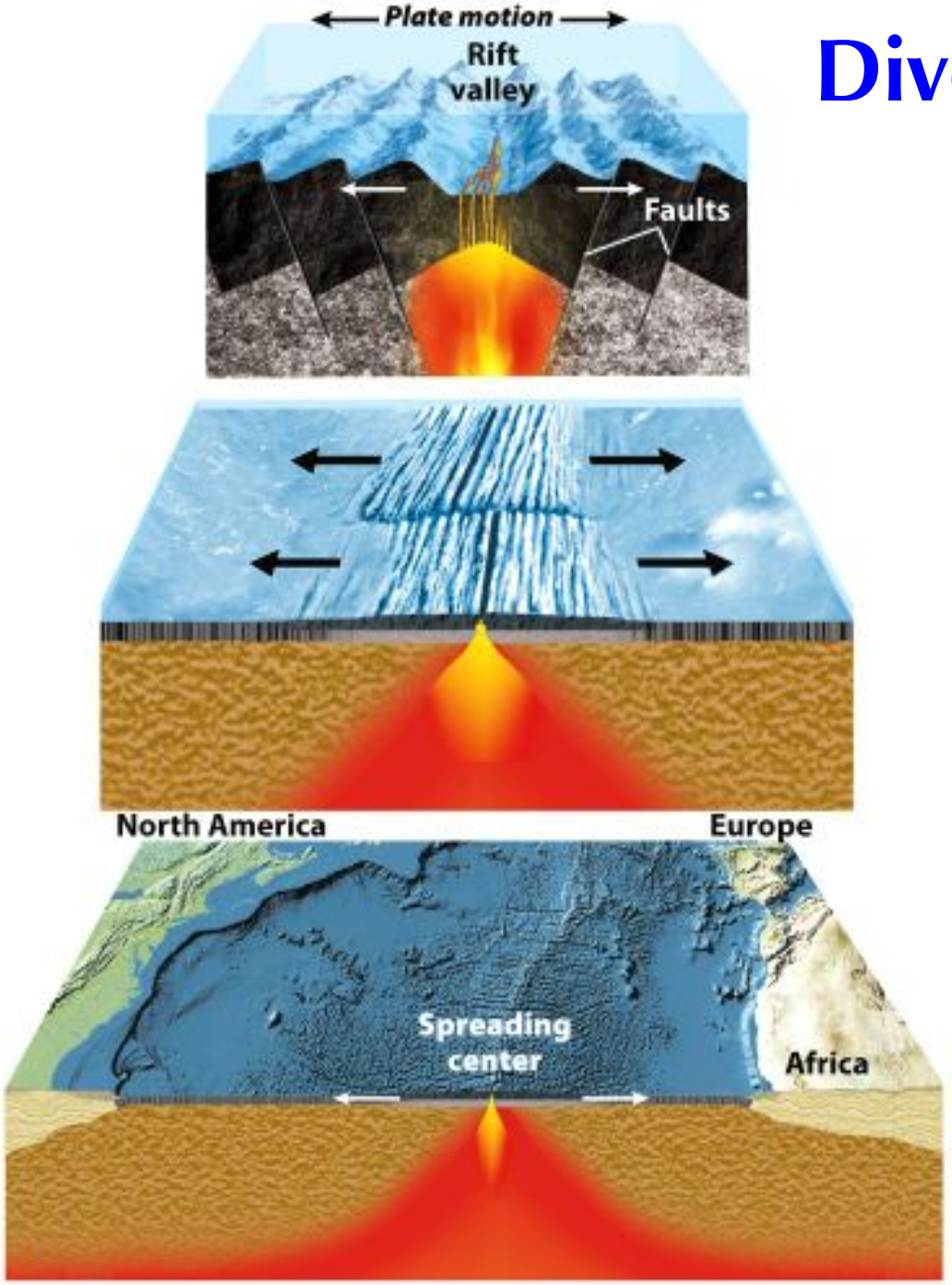
a. Stationary plate & a moving plume
b. Stationary plume & a moving plate
c. Moving plume & moving plate
d. Stationary plume & stationary plate

Plate Boundaries



Three types of plate boundaries

- Divergent (move apart)
- Convergent (come together)
- Transform (move side by side)

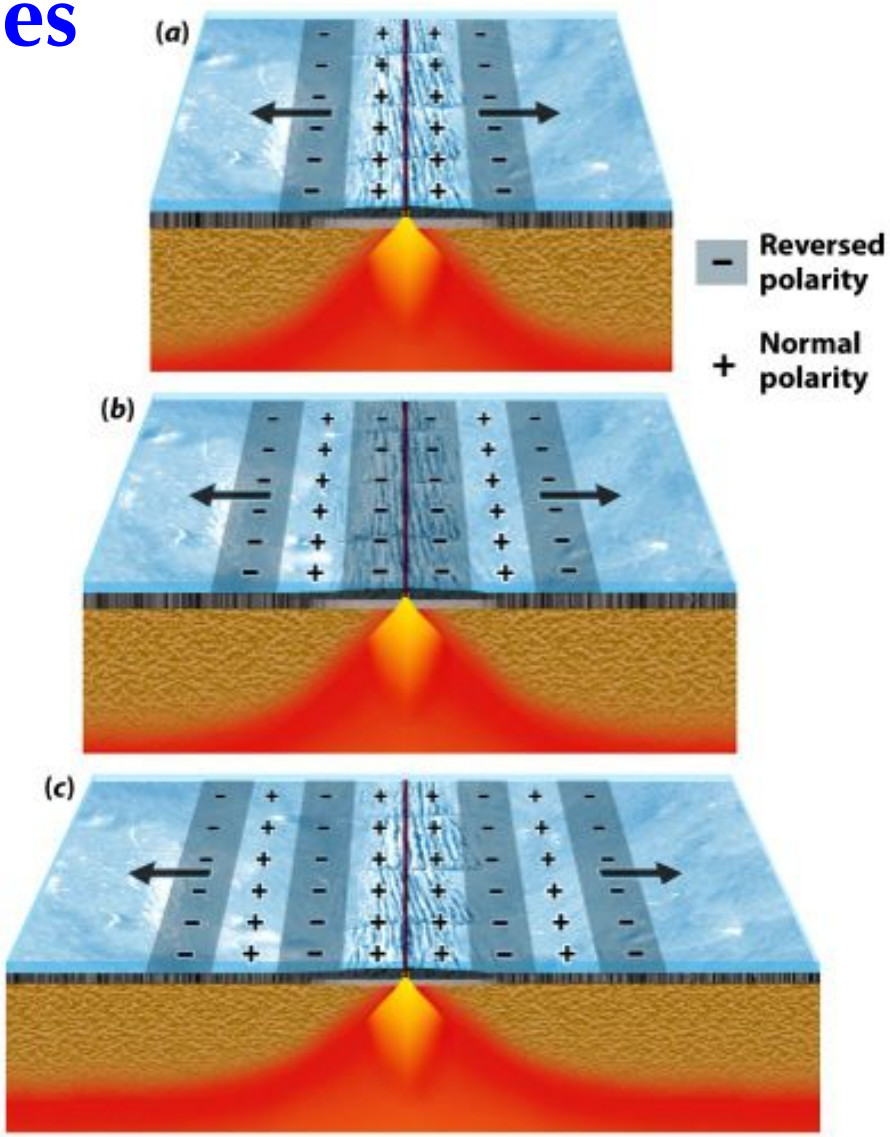


Divergent Boundary

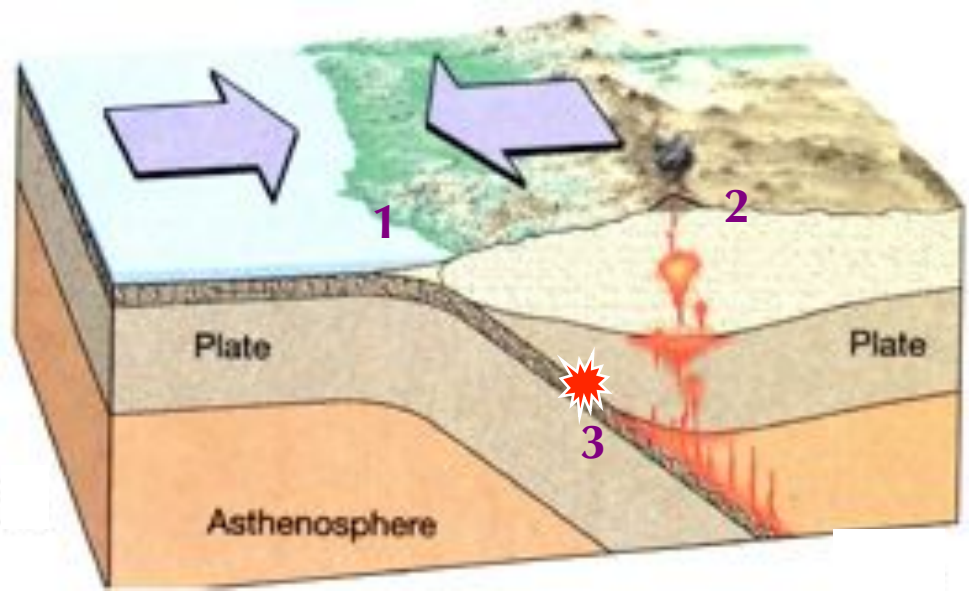
As two plates continue to move apart, the rock in the seafloor grows older as its distance from the rift zone increases

Paleomagnetism at Divergent Plate Boundaries

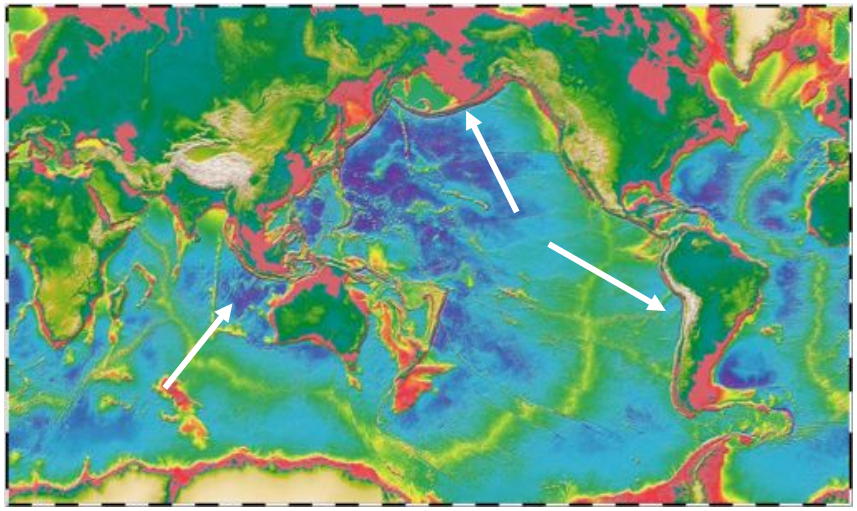
- Two plates pull apart
- New molten material rises through Rift Zone
- Like conveyer belts, the newer crust travels away from the center on each side.
- Oceanic crust records reversed and normal polarity episodes



Convergent Plate Boundaries



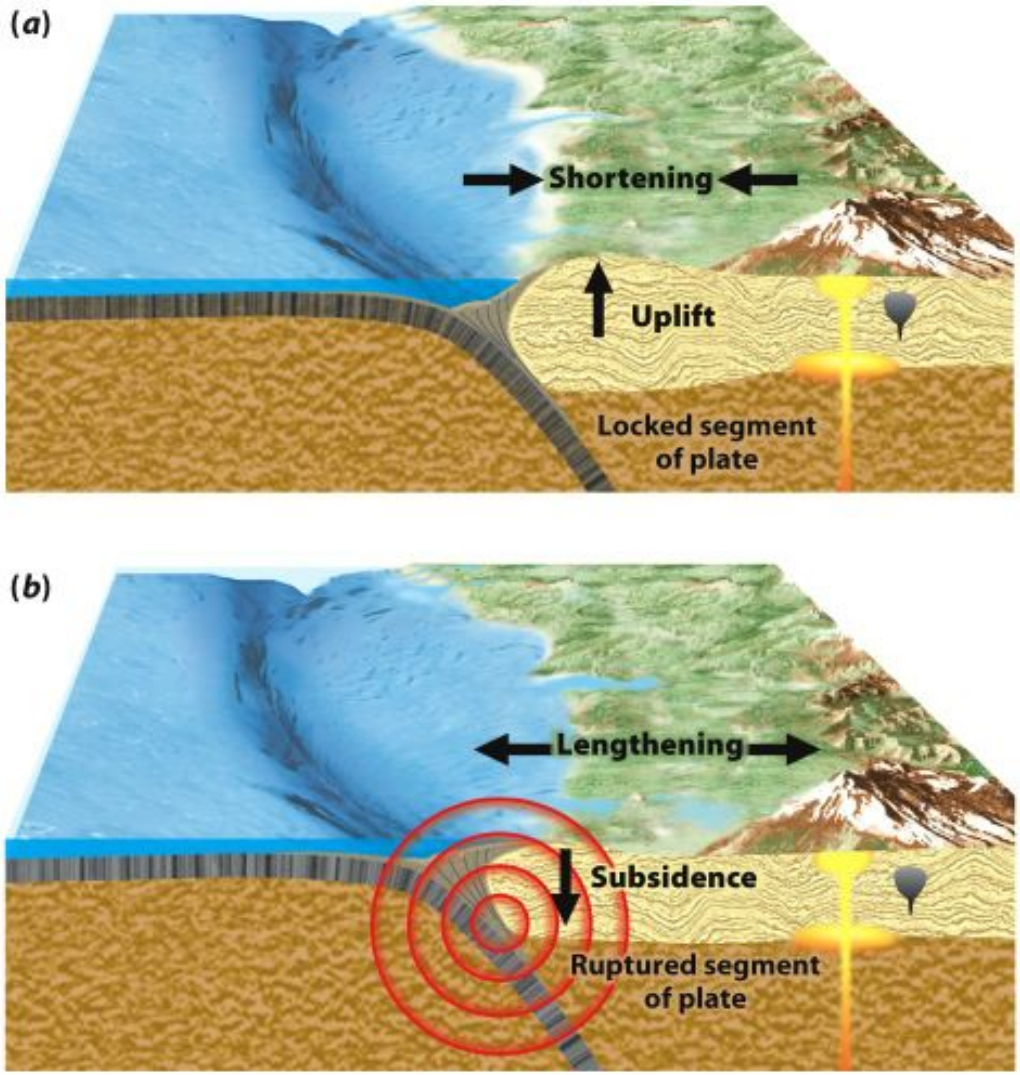
- Plates collide
- Subduction zones
- We observe:
  1) Trench
  2) Volcanoes
  3) Earthquakes



- Examples
  - Peru-Chilean Coast
  - Alaskan Coast
  - Sumatran Coast

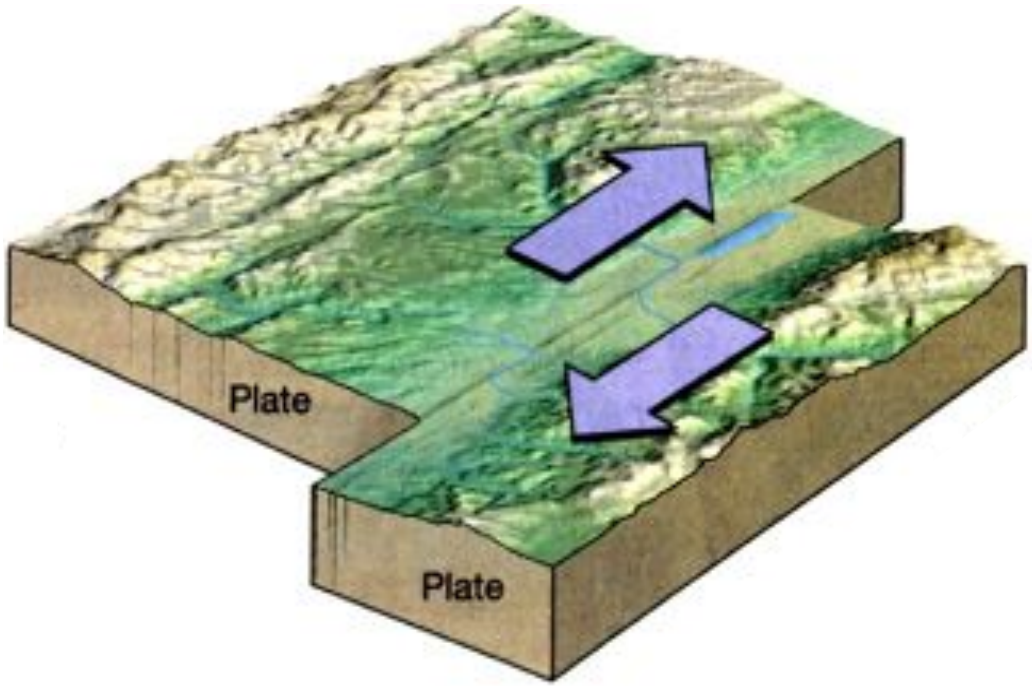
Megathrust Earthquakes

Occurs when "locked" subduction zone ruptures

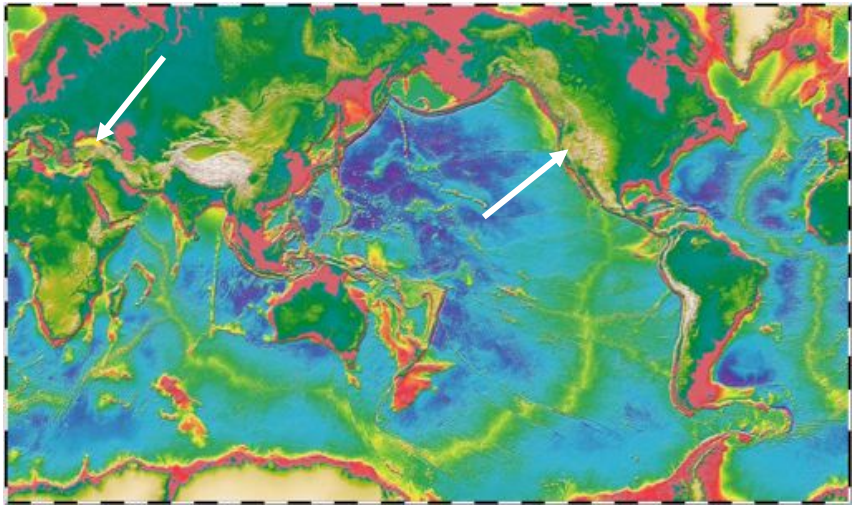


1. Strain accumulates.
2. Crust shortens.
3. Uplift occurs.
4. Plates unlock.
5. Crust extends rapidly, culminating in a megathrust earthquake

Transform Plate Boundary



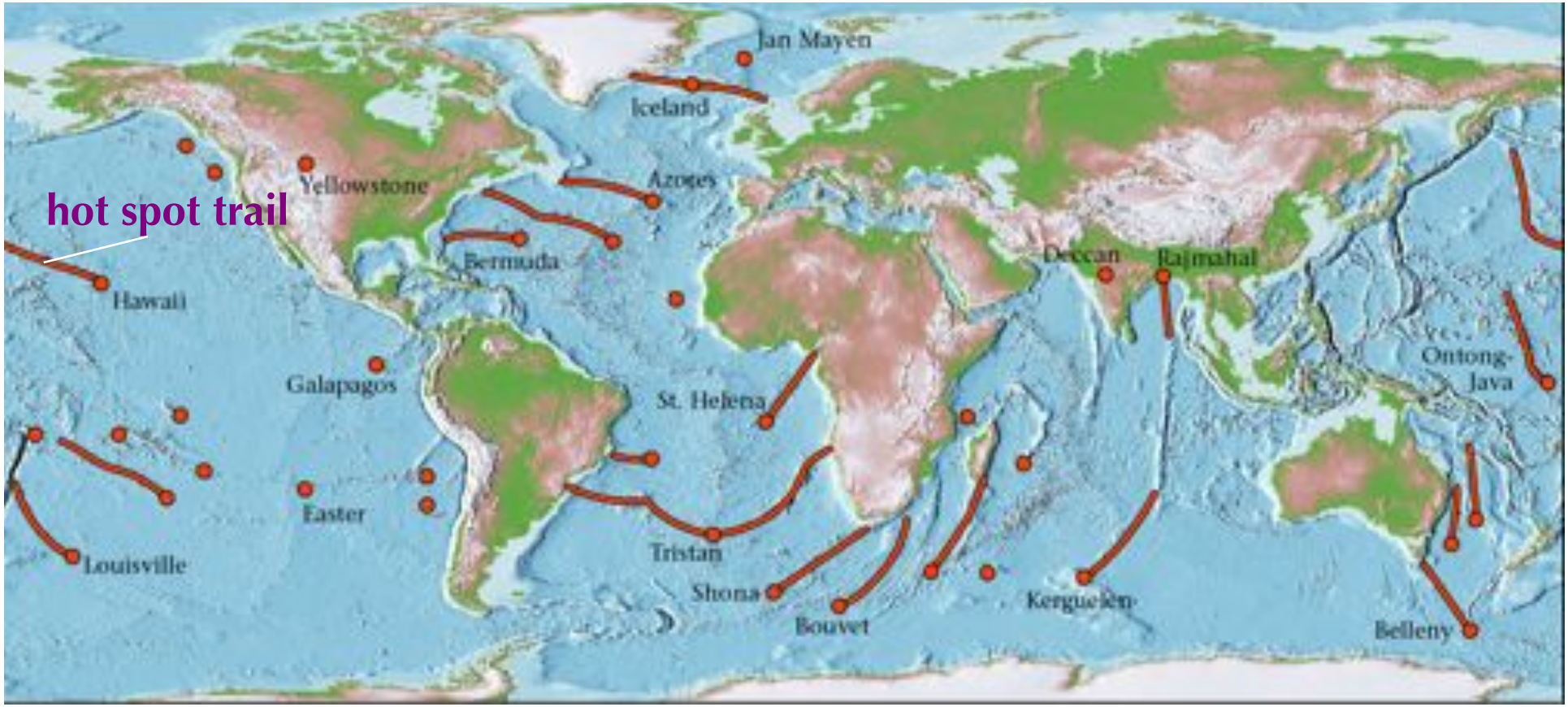
- Plates slide by
- Transform faults
- We observe:
  1) Offset surface features
  2) Earthquakes



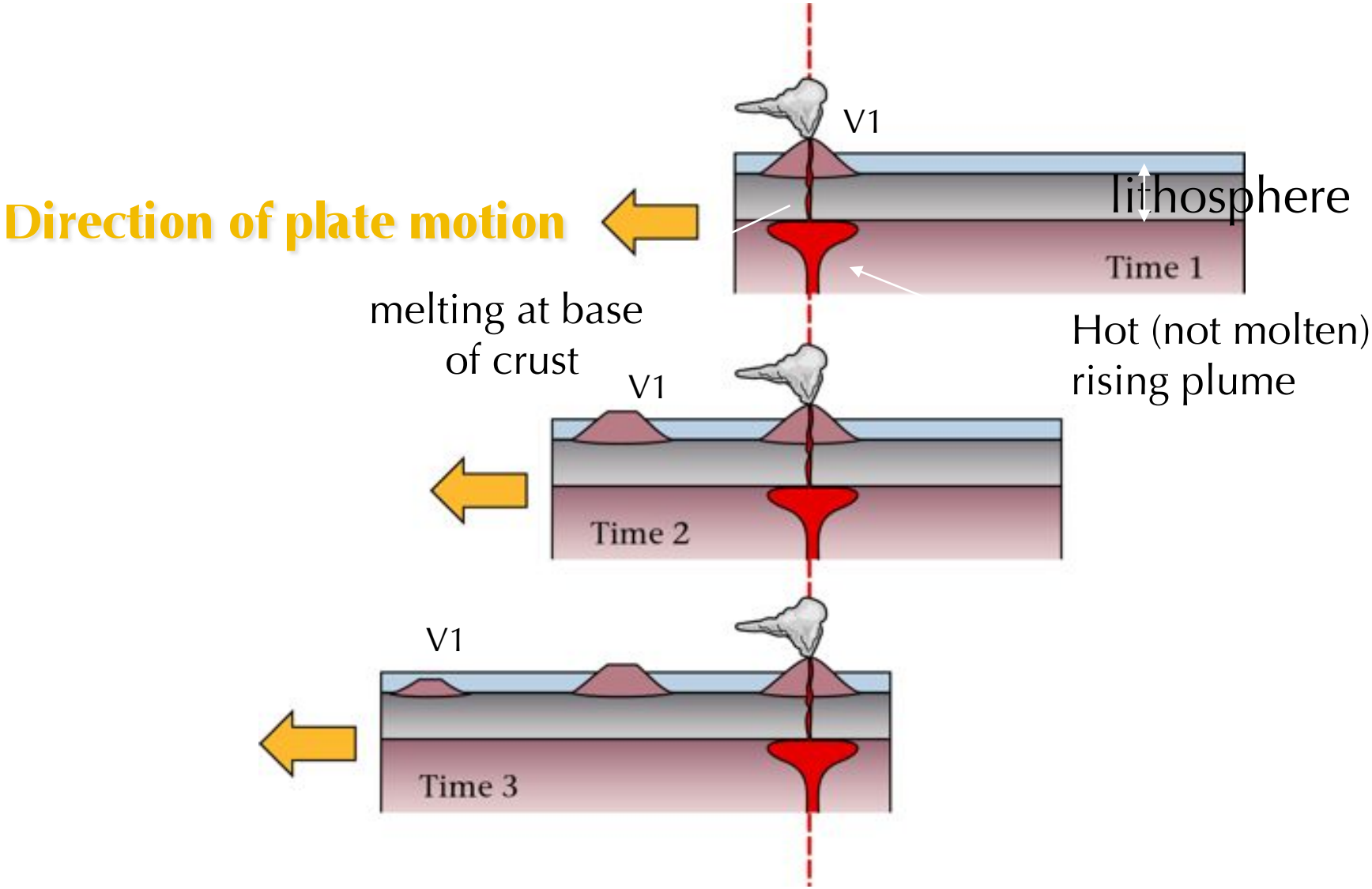
- Examples
  - San Andreas Fault
  - North Anatolian Fault (Turkey)

Hot Spots

- sometimes marked by chain of islands
- less common than plate-boundary volcanoes
- different composition (deep source)



Formation of Island Chains



Basic Premise of Plate Tectonics

- Earth's crust is divided into plates
- Plates move relative to one another at 1-15 cm/yr
- Plate interiors are largely undisturbed
- Deformation is concentrated at plate boundaries

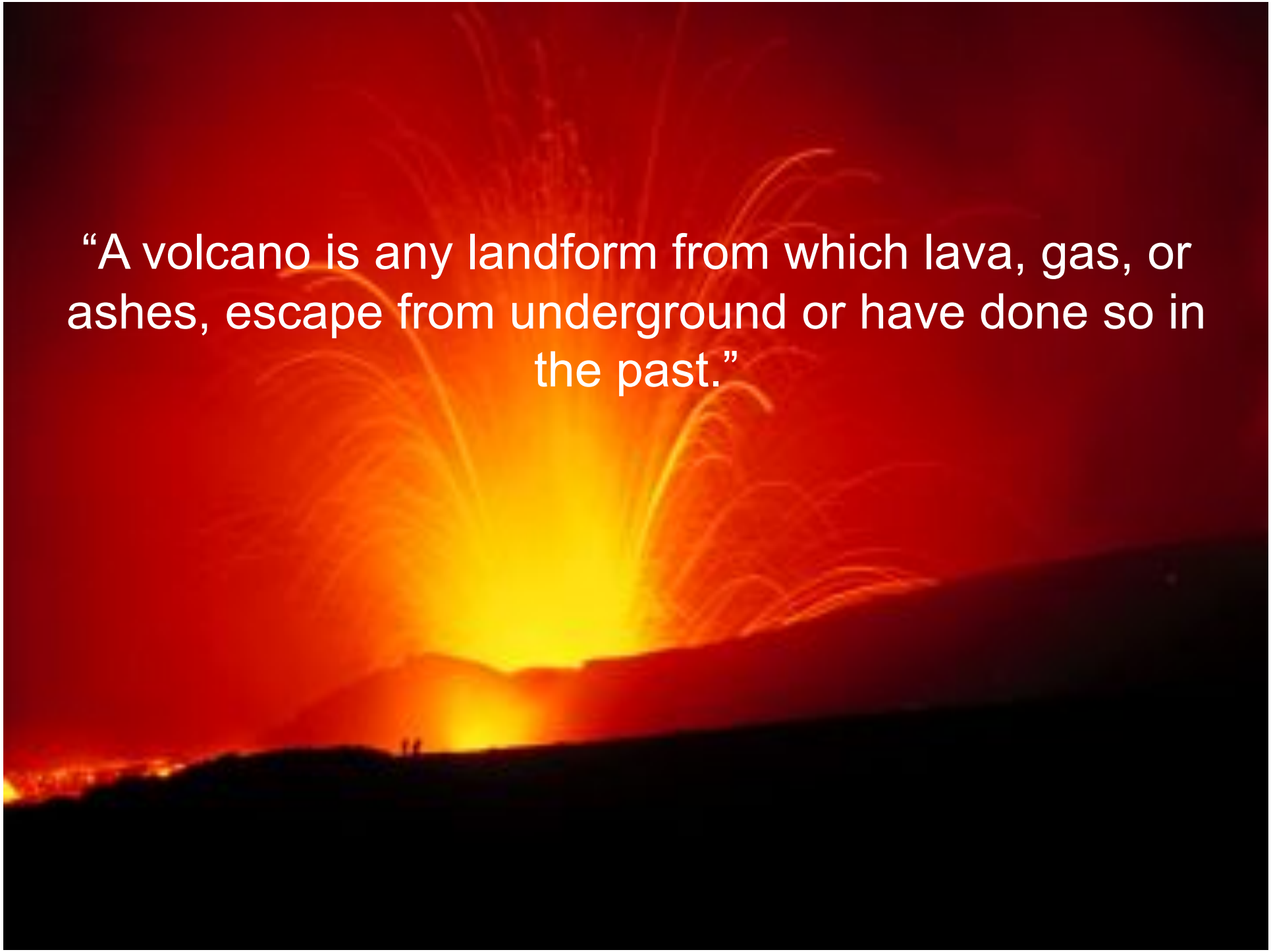
Consequences:

- Plate tectonics constantly change Earth's surface
- Earthquakes occur mostly at plate boundaries
- Volcanoes occur mostly at plate boundaries

Learning Objectives (LO)

Lecture 12: Volcanoes
Read: Chapter 6

1. Define the term volcano and explain why geologists study volcanoes
2. Compare and contrast 3 common types of magma
3. Describe volcanic gases and the role they play in explosive vs effusive eruptions
4. Identify what gives a shield volcano its distinctive shape


“A volcano is any landform from which lava, gas, or ashes, escape from underground or have done so in the past.”

The Rocks of Volcanoes

	Rhyolite	Andesite	Basalt
Extrusive			

melt at low temperature ⟷ melt at high temperature

Felsic — Intermediate — Mafic — Ultramafic

⟷ Composition

Three Common Types of Magma:

BASALTIC

ANDESITIC

RHYOLITIC

Three Common Types of Magma:

BASALTIC

Basaltic lava flows easily because of its low viscosity and low gas content.

The low viscosity is due to low silica content.

Aa - rough, fragmented lava blocks called “clinker”

Pahoehoe - smooth, shiny, and ropy surface

Three Common Types of Magma:

ANDESITIC

- Erupts explosively because it has high gas content
- It is viscous and therefore traps gas.
- High viscosity is related to high silica content

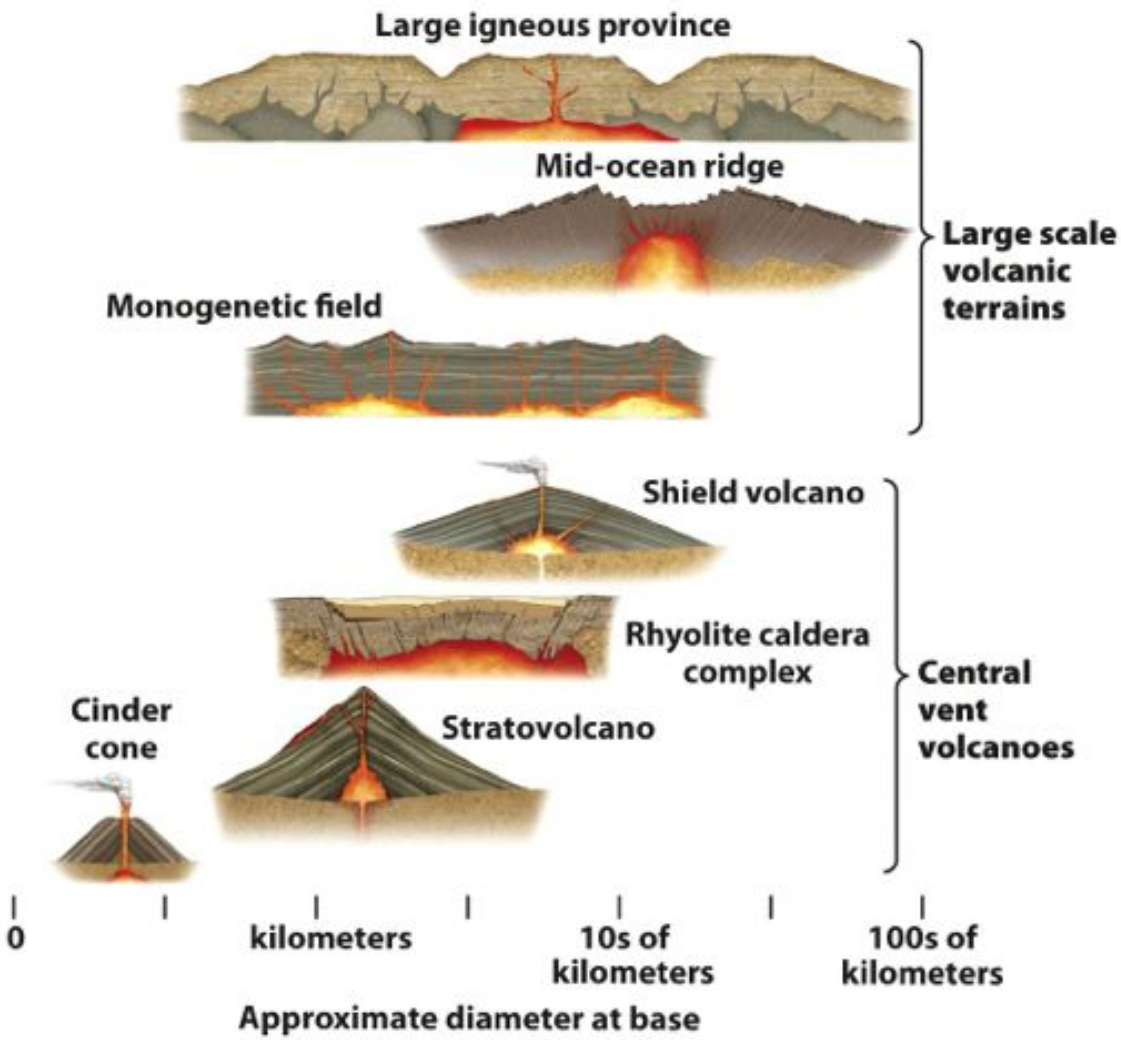
Three Common Types of Magma:

Rhyolitic lava flow

RHYOLITIC

- **Erupts catastrophically because it has high gas content.**
- **It is viscous and therefore traps gas, builds pressure and explosively erupts.**
- **High viscosity → high silica content**

Volcanoes can be classified into 6 major types based on their size, shape, and origin



Large-scale Volcanic Terrains

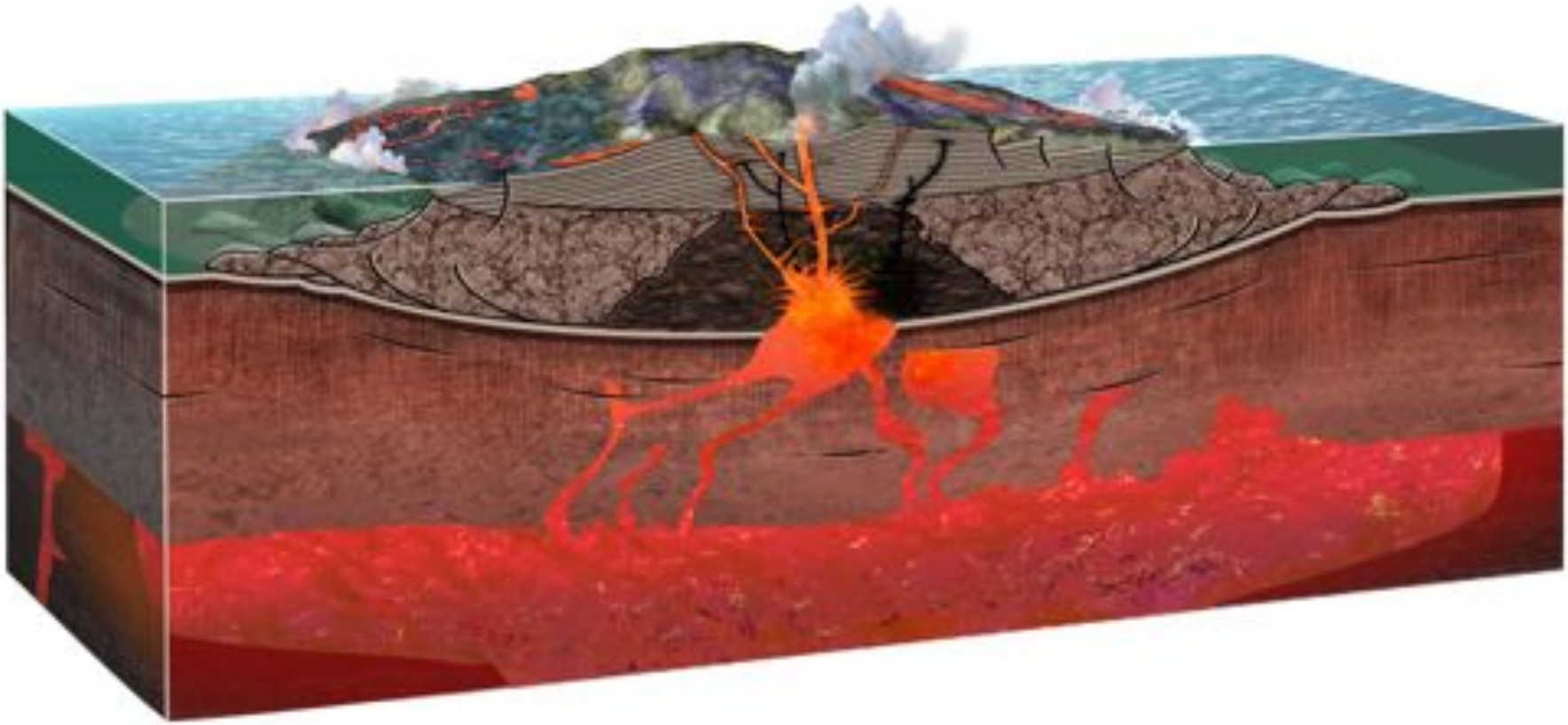
- No central vent
- Network of source material
- Generally massive

Central Vent Volcanoes

- Central vent
- Summit crater
- Flank eruptions
- Fissure eruptions

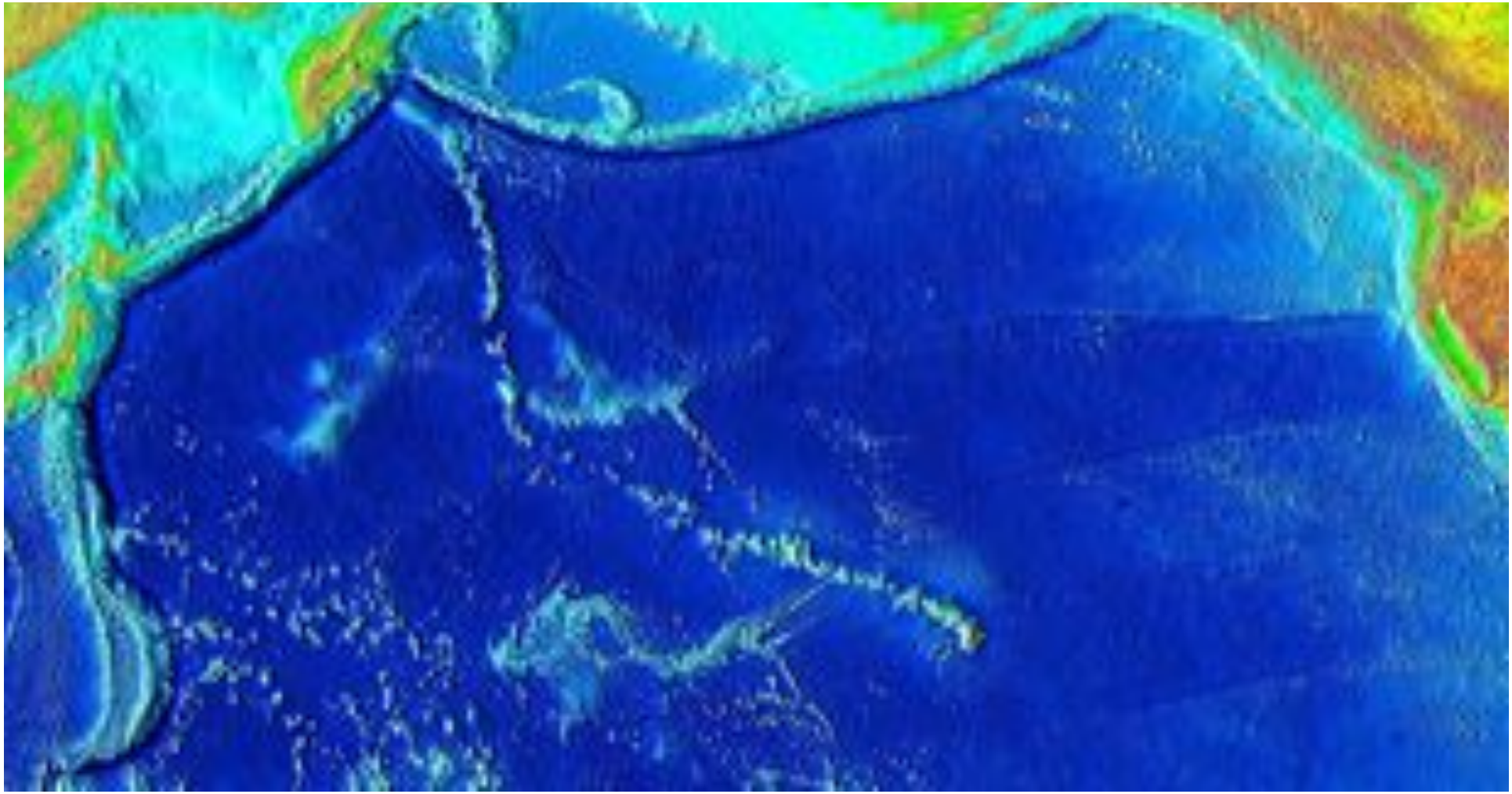
Shield Volcano

- Low silica, low gas magma originates in the mantle.
- Fluid, basaltic lava results in “Aa” and “Pahoehoe”.
- Low viscosity creates broad, gentle slopes.
- **Phreatomagmatic eruptions** occur when lava contacts water (rapid expansion of steam) .

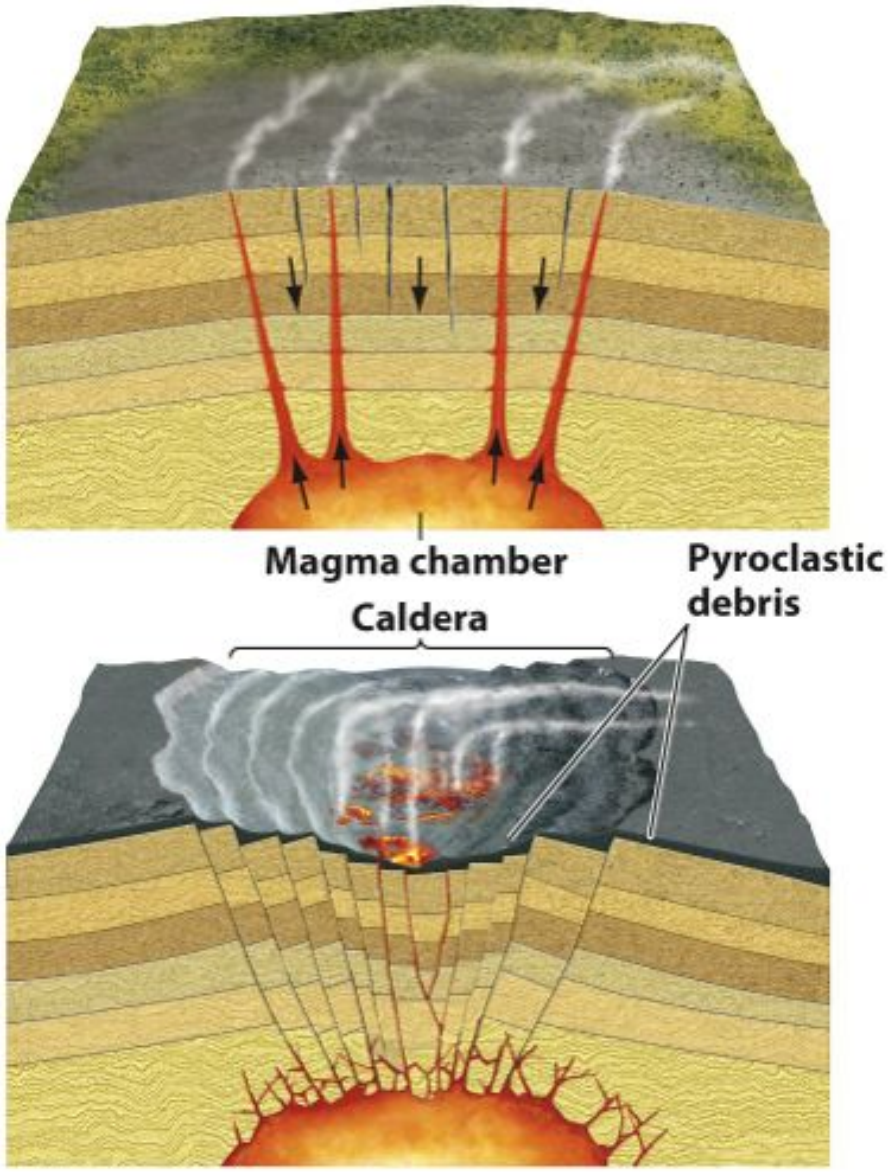


Shield Volcanoes in Hawai‘i

- Eight main islands are exposed tips of the Hawaiian Ridge.
- Age range is modern to ~6 million years old.
- Volcanoes develop as the Pacific Plate moves across the Hawaiian Hotspot.



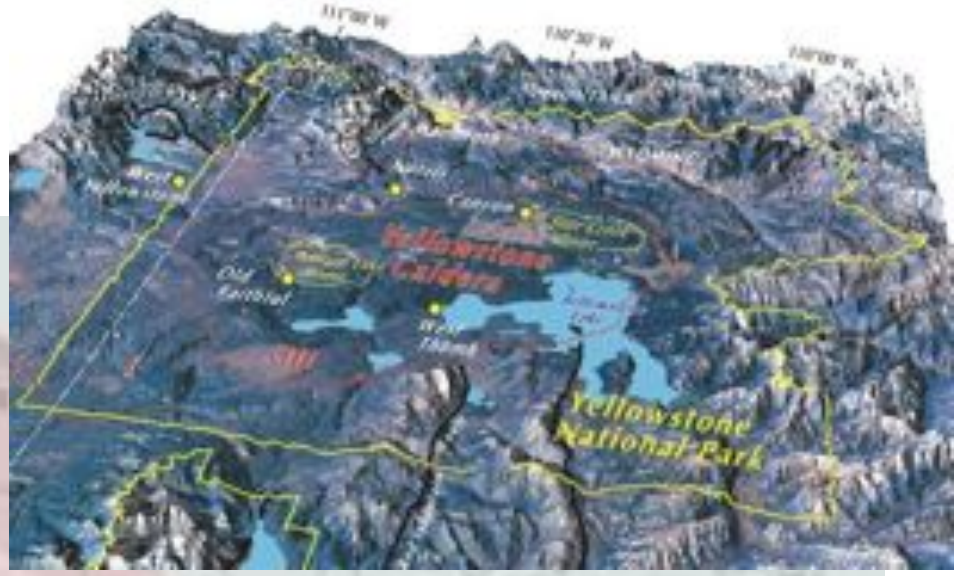
Features of Rhyolite Caldera Complexes

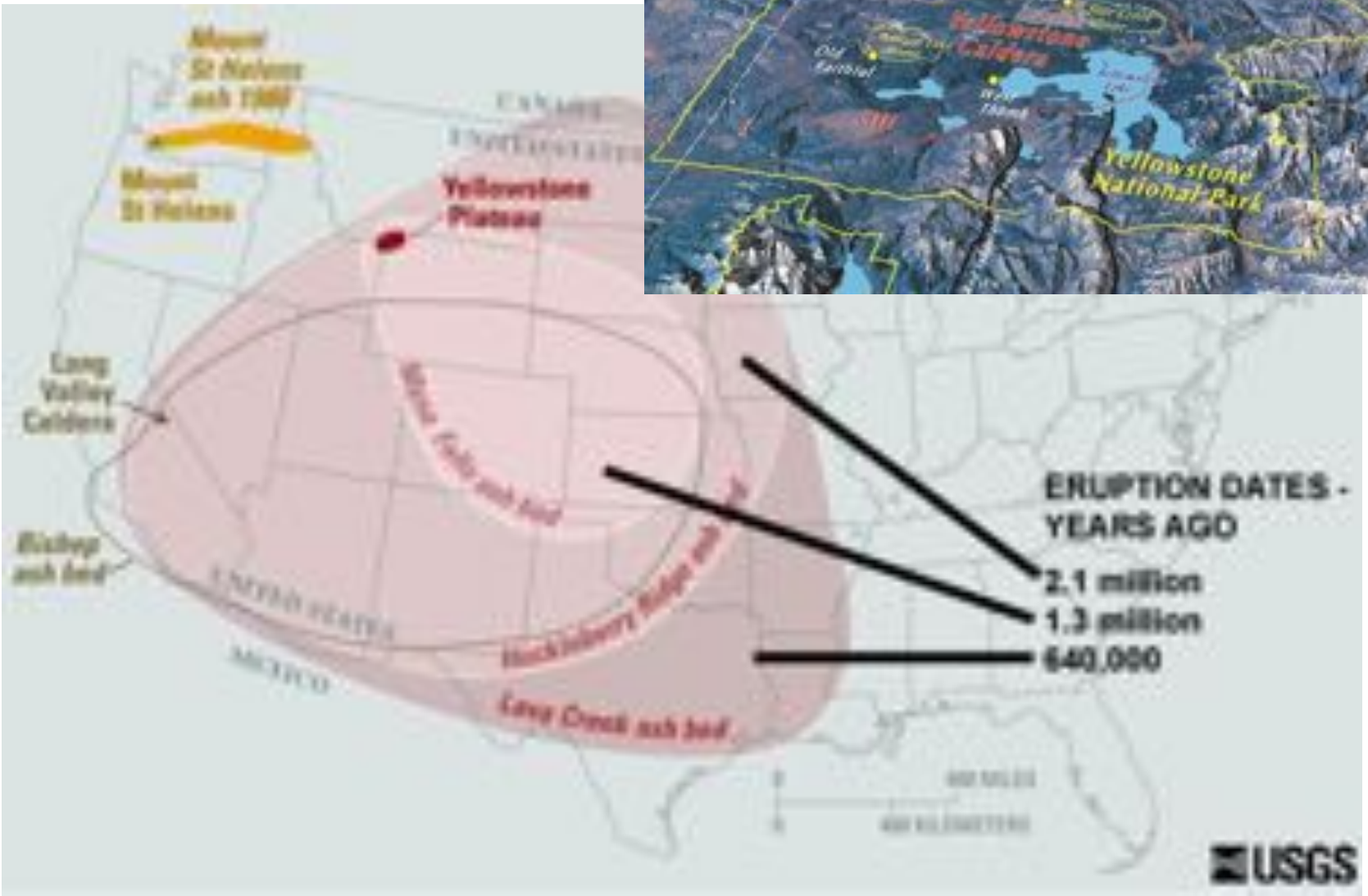


High-silica, high-gas magmas. Massive explosions (most explosive of all types).

- Collapse, producing an "inverse volcano", or Caldera (Spanish for cauldron).

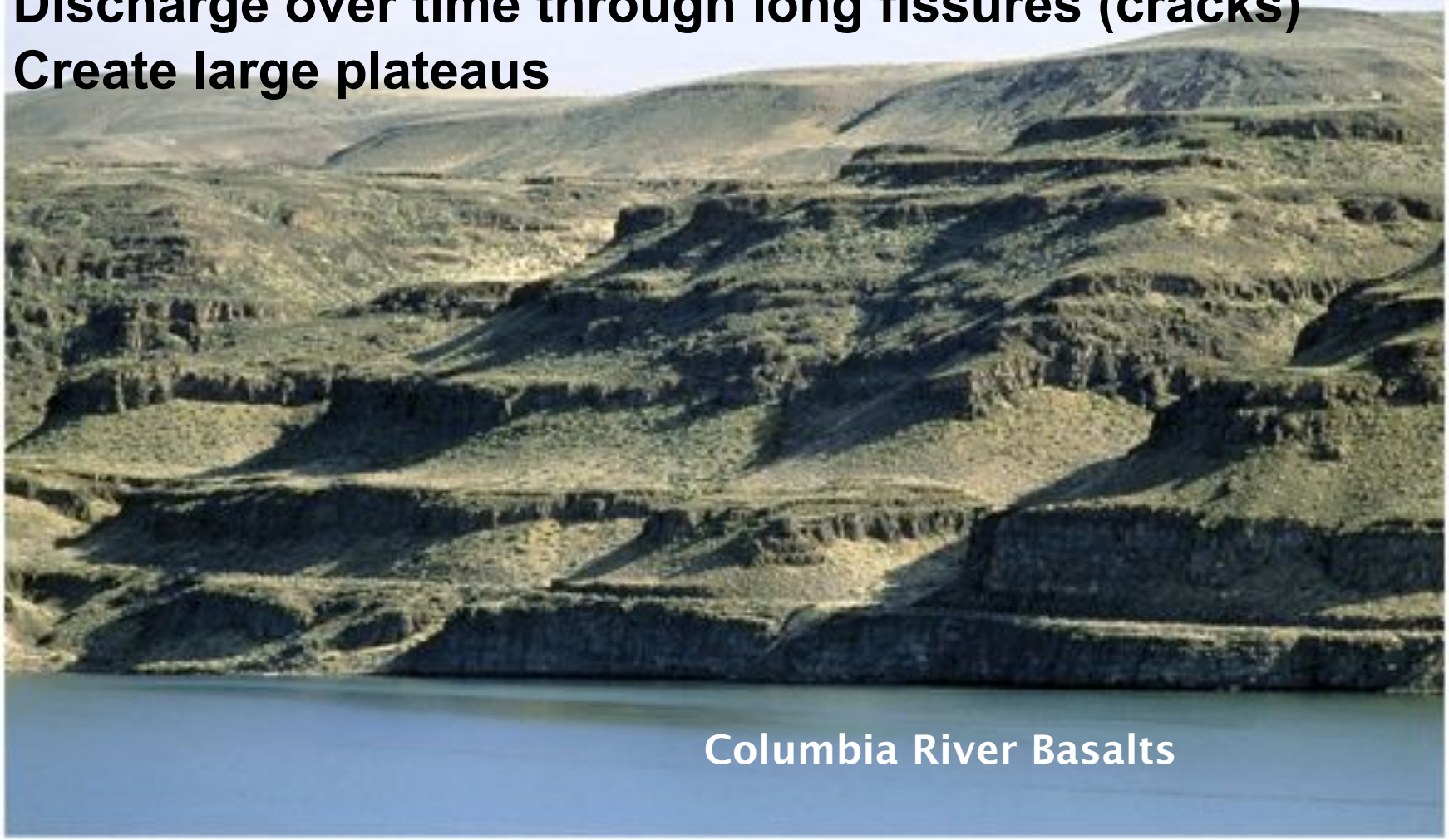
Yellowstone ash beds cover much of the western USA





Large Igneous Province

Fed by massive mantle plumes
Caused by flood basalts
Discharge over time through long fissures (cracks)
Create large plateaus



Learning Objectives (LO)

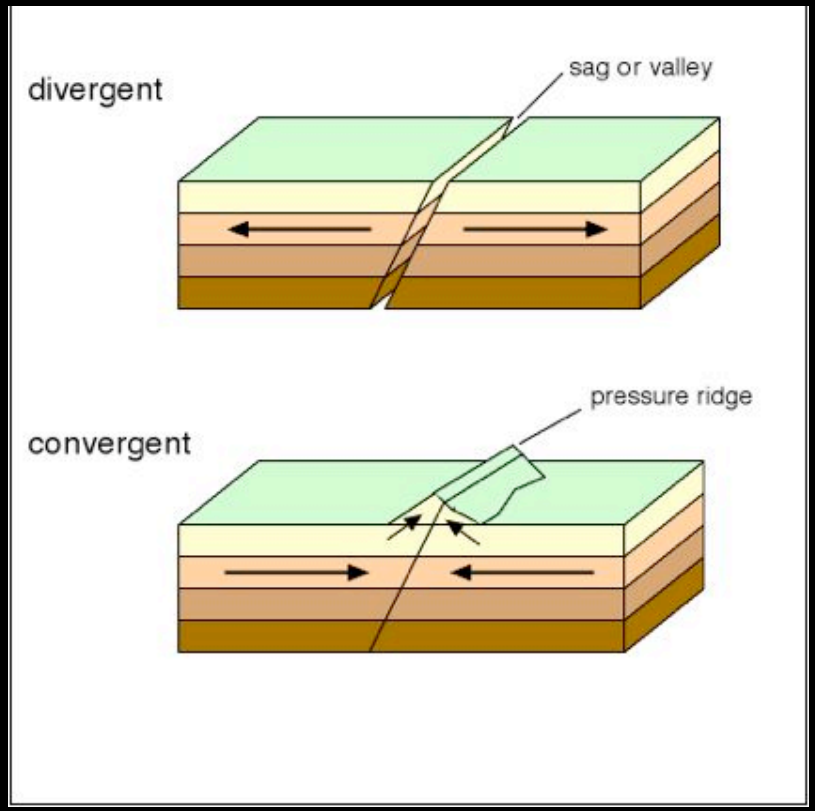
Lecture 13: Mountain Building
Read: Chapter 10

1. Define the types of stress that are present in the crust
2. Define the 3 stages of strain
3. Compare volcanic, fault-block, and fold-thrust mountains
4. Describe the origin of the Basin and Range Province

iClicker Question

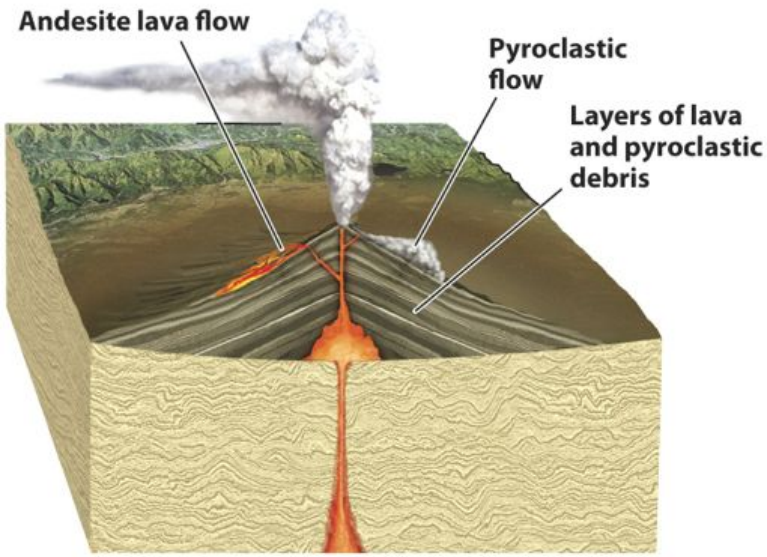
A convergent margin is characterized by _____ stress and a divergent margin is characterized by _____ stress.

a) Tensional; shear
b) Compressive, shear
c) Compressive; tensional
d) Shear; shear
e) None of the above

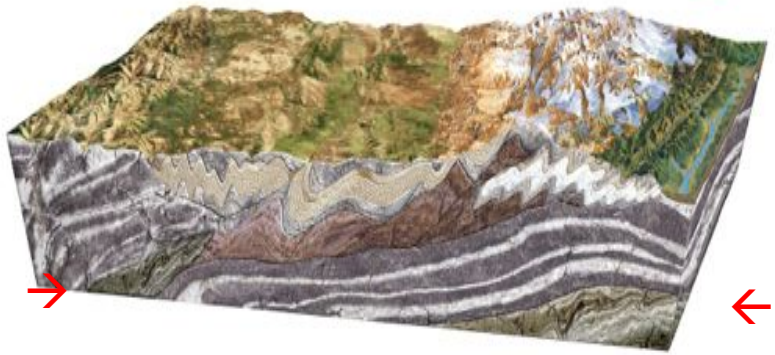


3 Types of Mountains

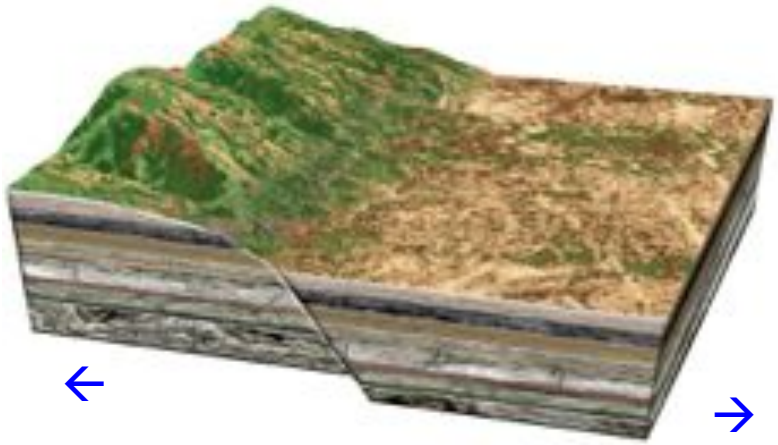
Volcanic Mountains:
Built by accumulation of volcanic materials

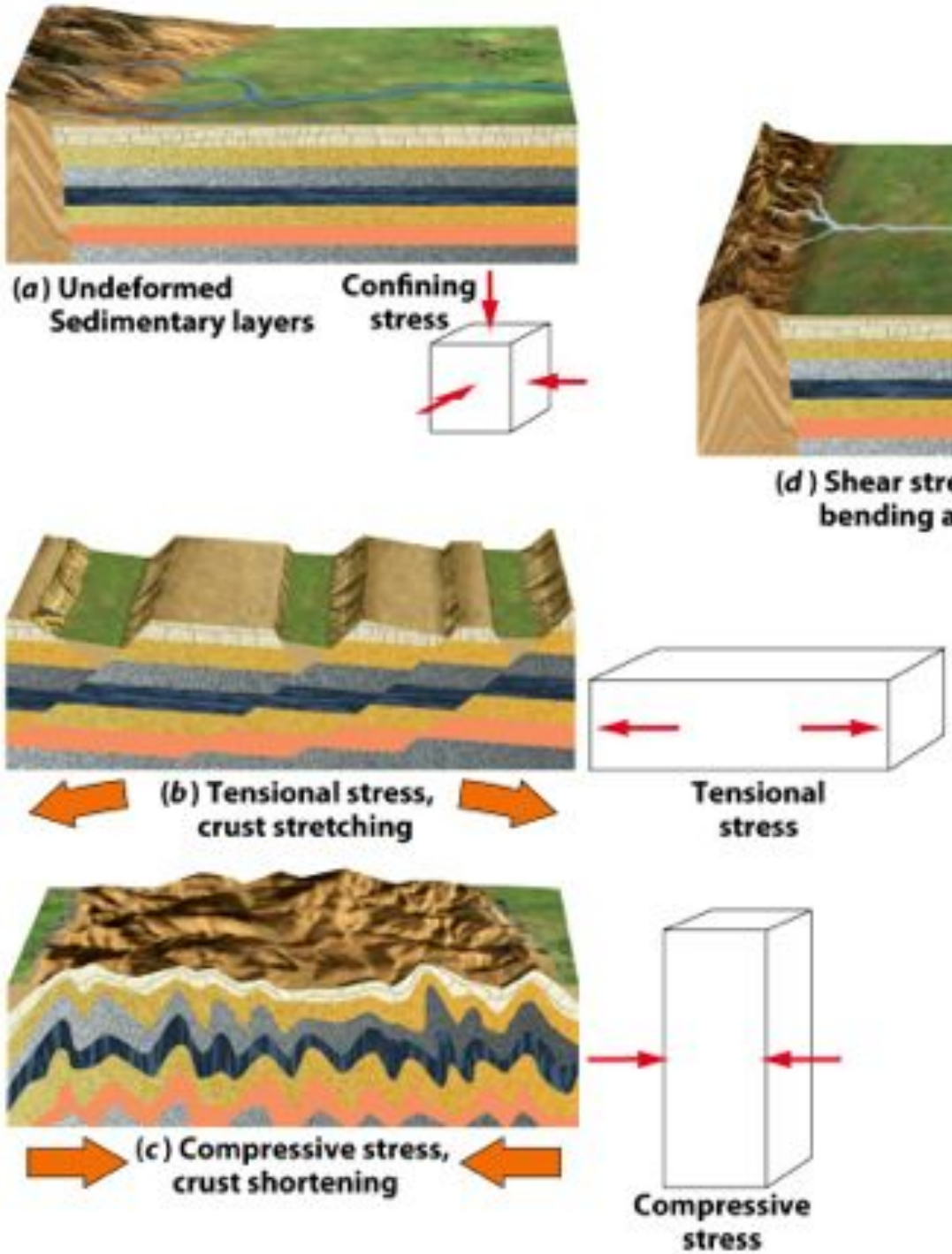


Fold and Thrust Belts:
Built by **compression** stresses



Fault Block Mountains:
Built by **extensional** stresses





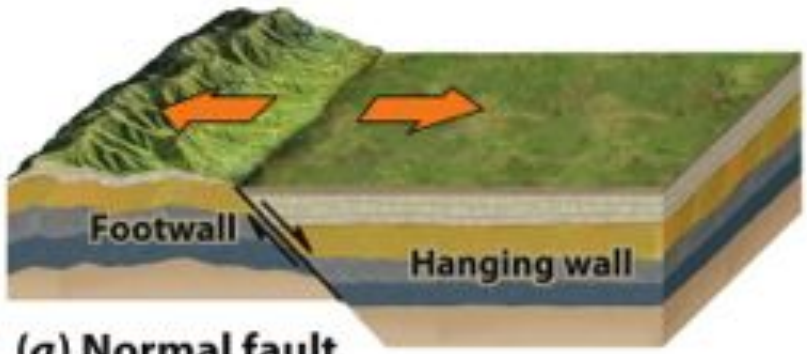
Stress can be:

- Tensional (stretching)
- Compressive (shortening)
- Shear (side-to-side)

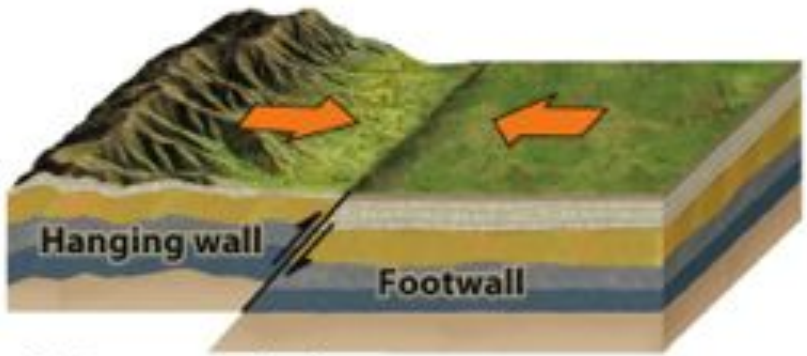
Major Types of Faults

Dip-Slip and
Strike-Slip faults

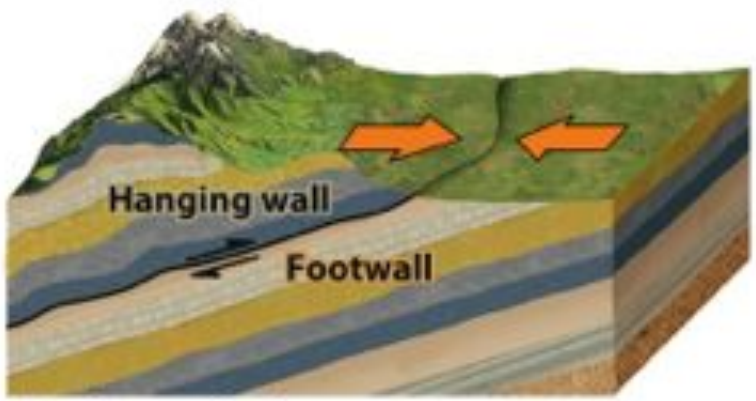
Dip-
Slip
Faults



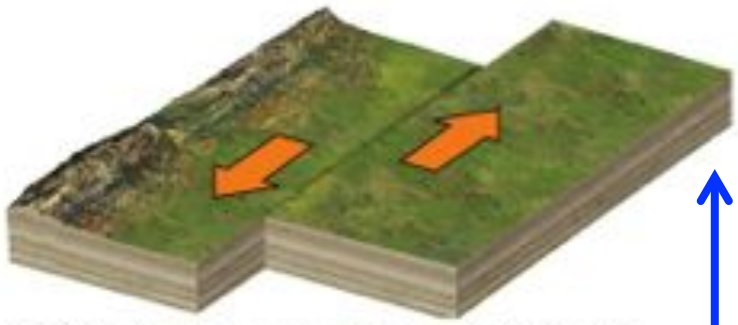
(*a*) Normal fault



(*b*) Reverse fault

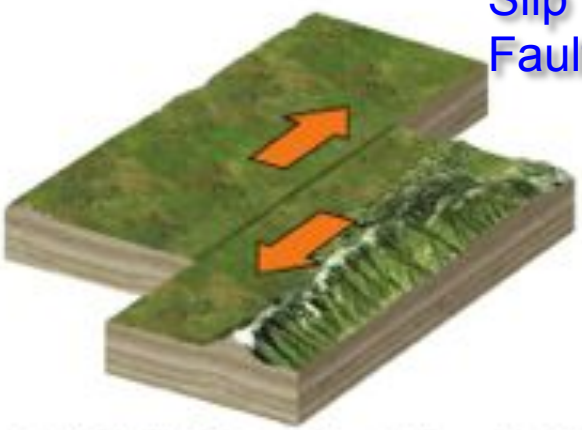


(*c*) Thrust fault



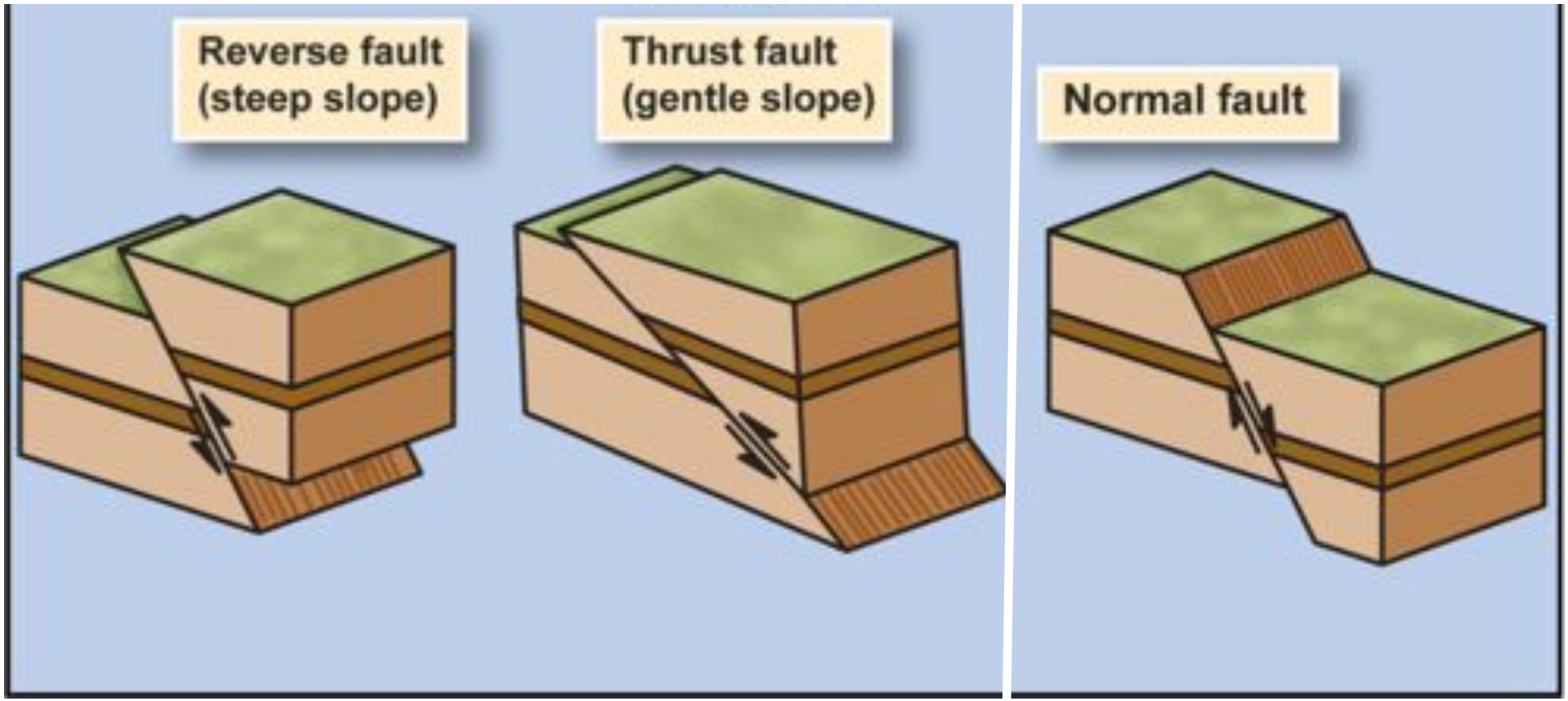
(*d*) Left lateral strike-slip fault

Strike-
Slip
Faults



(*e*) Right lateral strike-slip fault

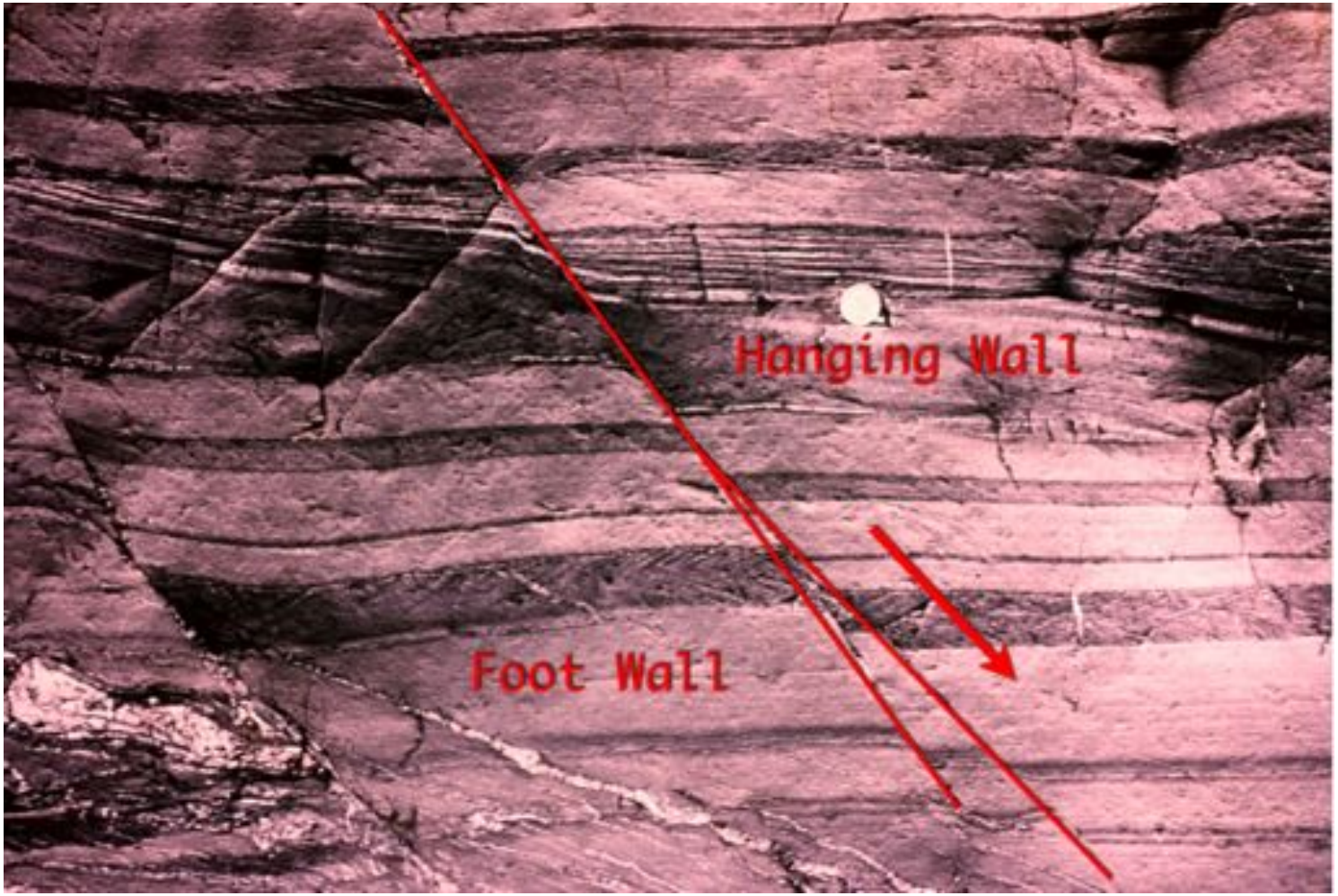
Dip-Slip Faults



Reverse

Normal

Normal Faults



iClicker Question

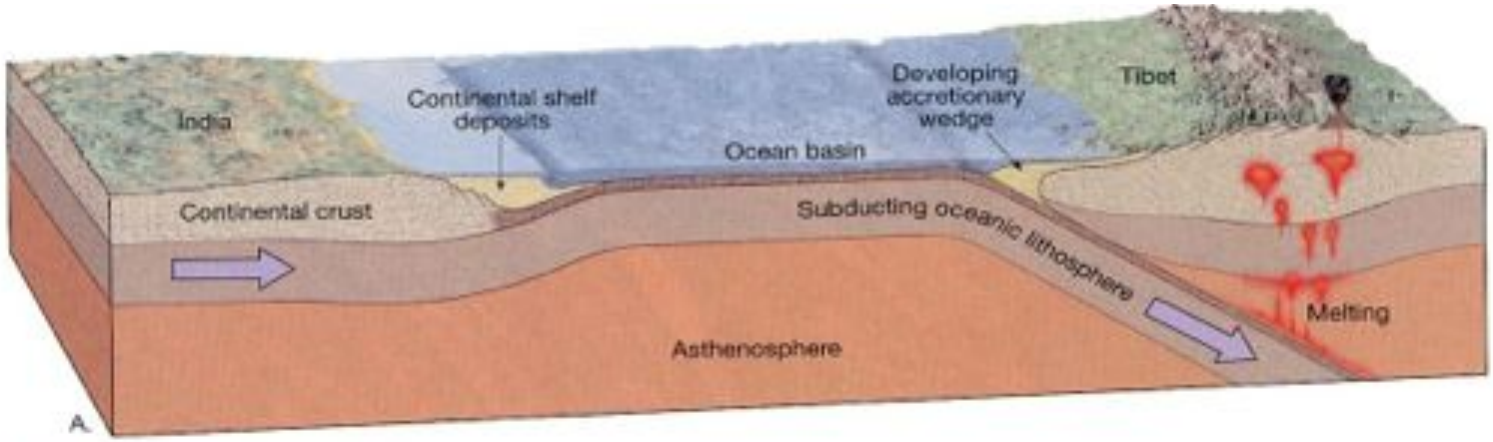
What type of dip-slip fault is this?

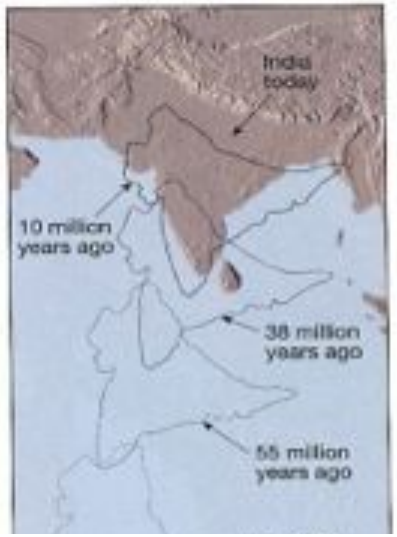
a. Normal
b. Reverse

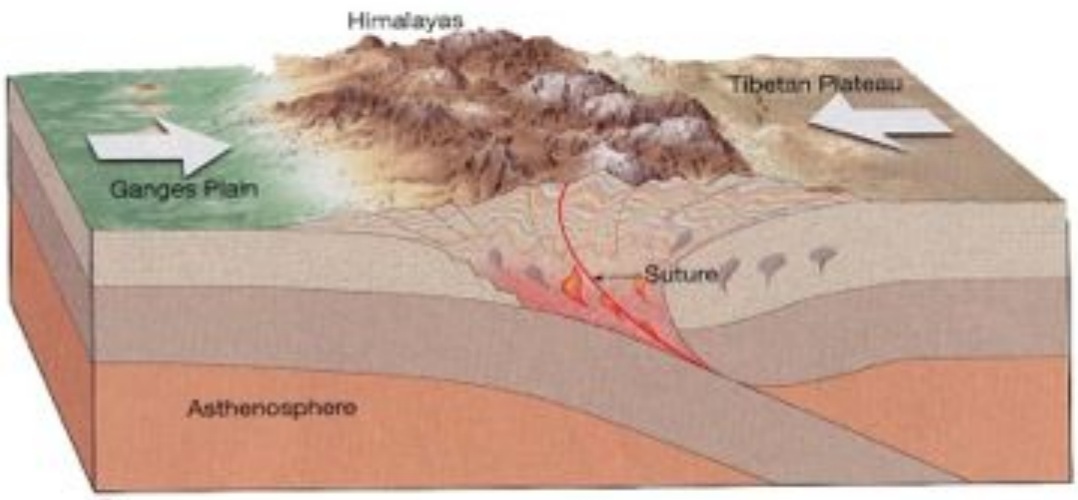
Fold and Thrust Mountains

The Himalayas

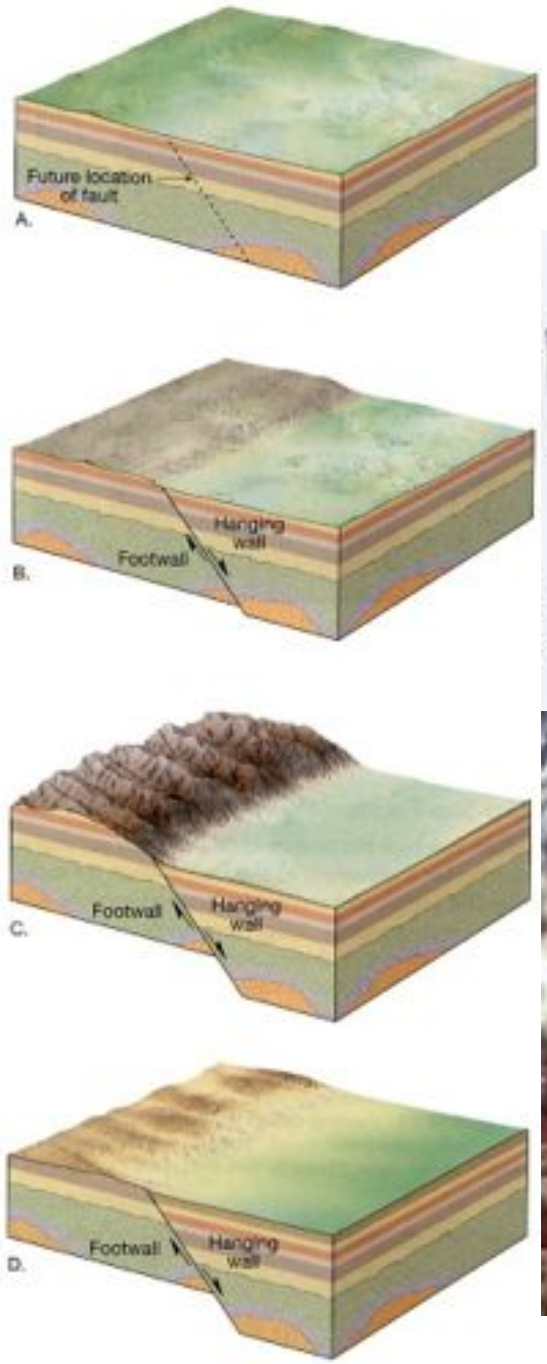
- Collision of India with Eurasia caused compressive stresses.
- These stresses raised the Himalayas and Tibet.

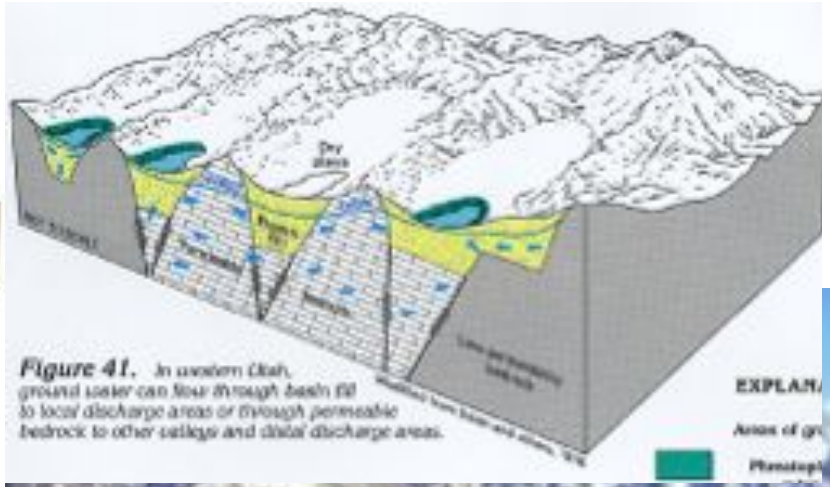


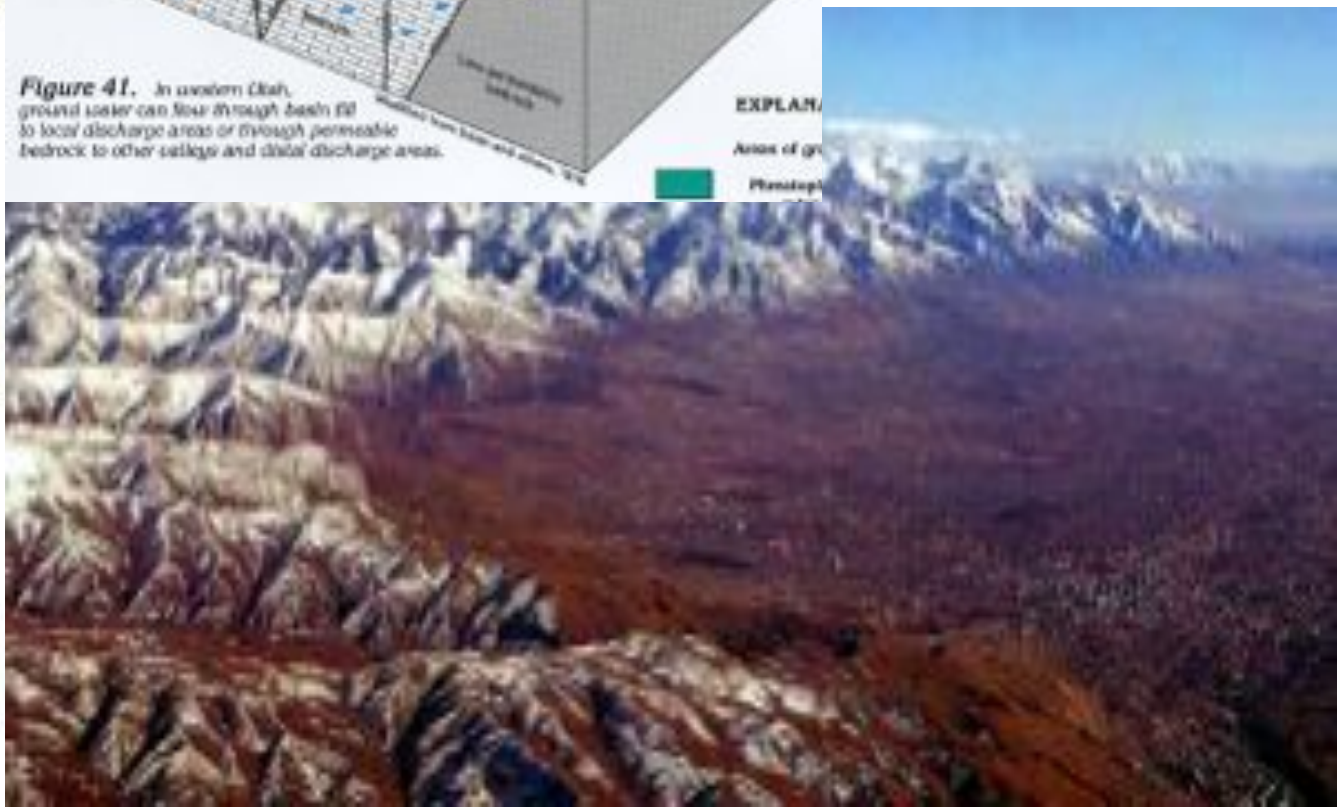




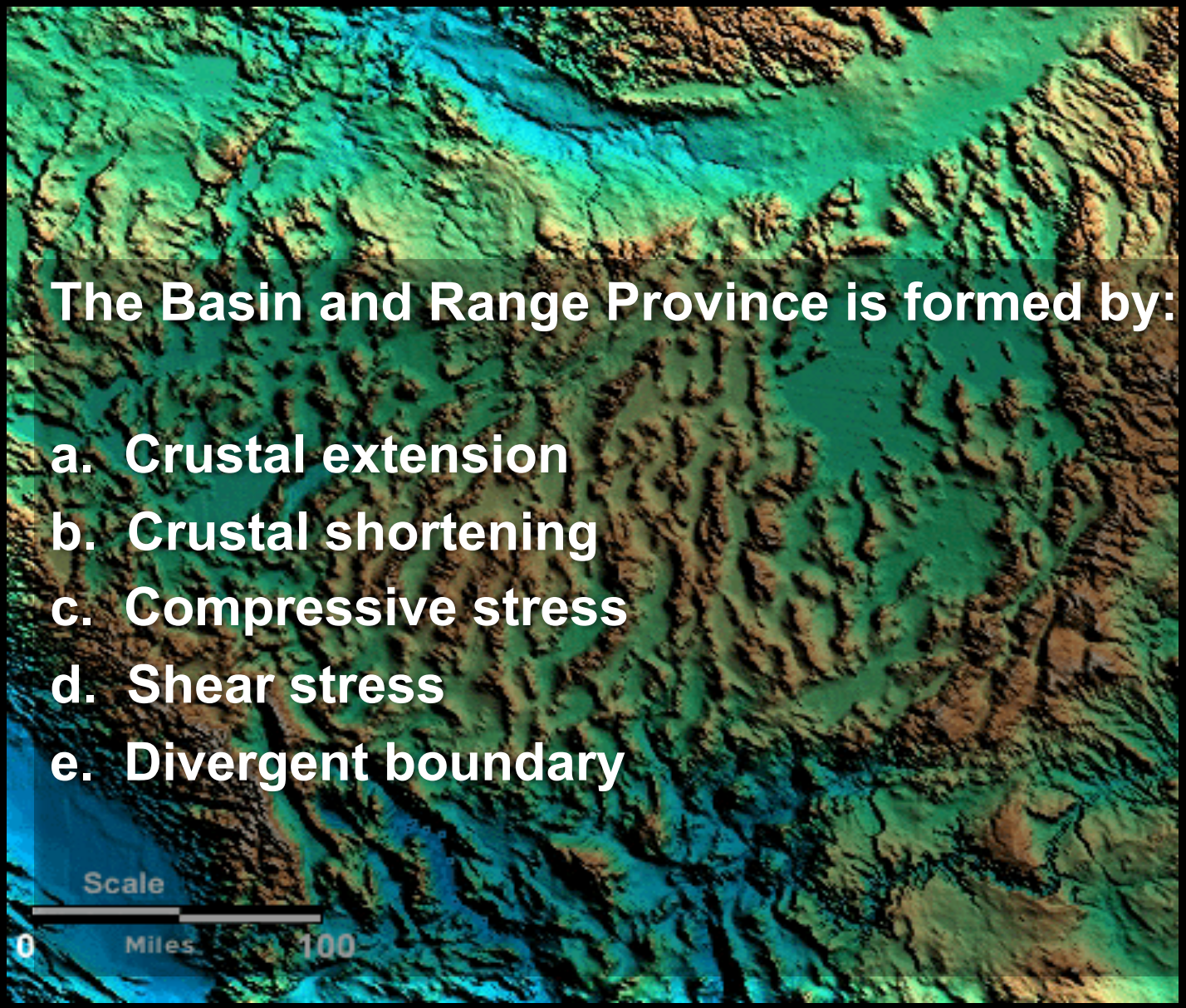
Fault Block Mountains: Tensional Stresses







iClicker Question

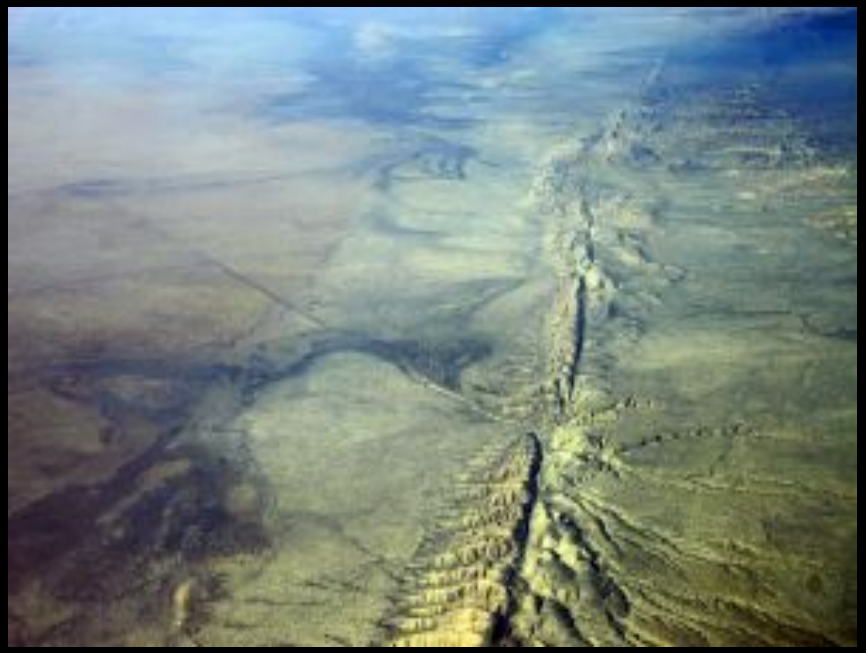


The Basin and Range Province is formed by:

a. Crustal extension
b. Crustal shortening
c. Compressive stress
d. Shear stress
e. Divergent boundary

Basin and Range Province, Western USA

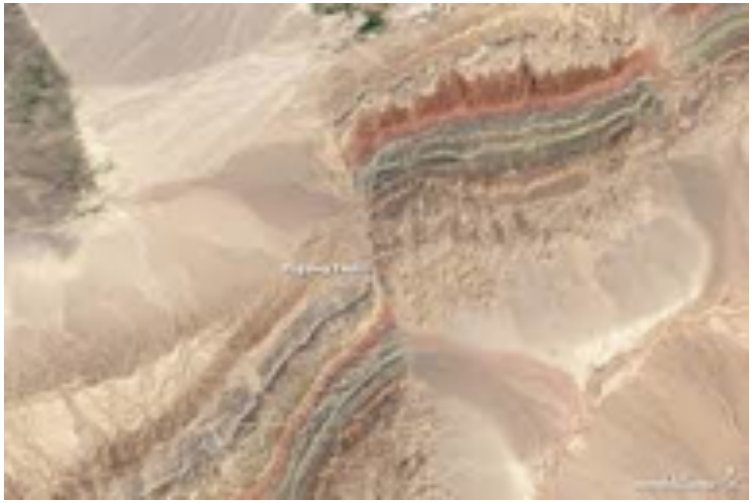
Learning Objectives (LO)



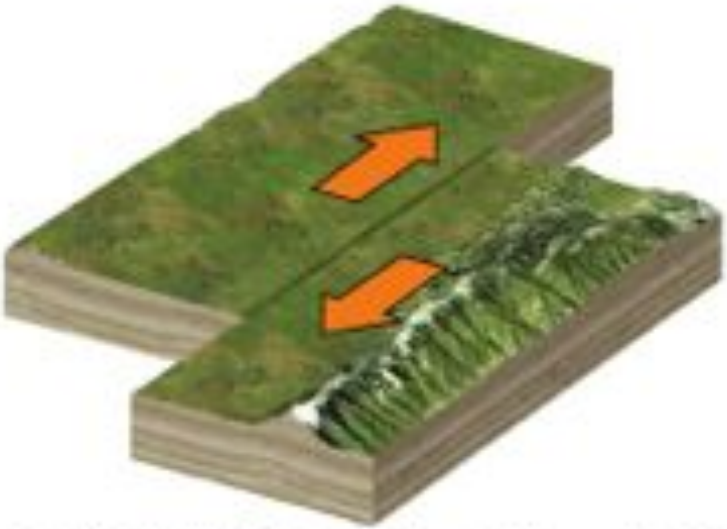
Lecture 14: Faults and Quakes
Read: Chapter 10 and 11

1. Compare strike-slip to dip-slip faults
2. Describe the boundary of the North American and Pacific Plates
3. Define elastic rebound theory

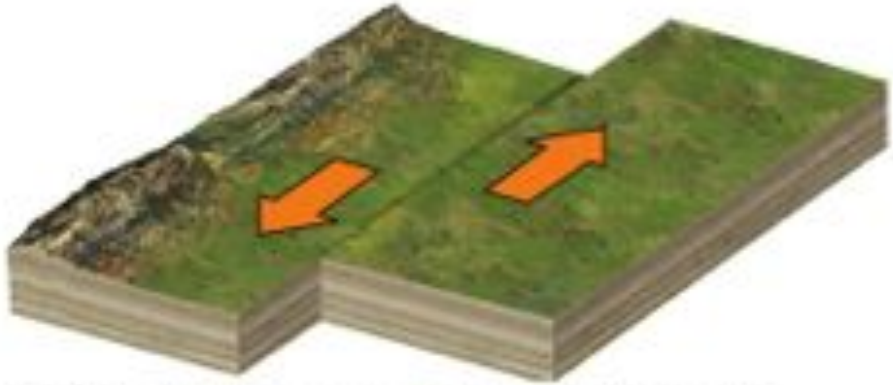
Strike-Slip Faults



Right- vs. Left- Lateral Strike Slip Faults



(e) Right lateral strike-slip fault



(d) Left lateral strike-slip fault

iClicker Question

What type of strike-slip fault is this?

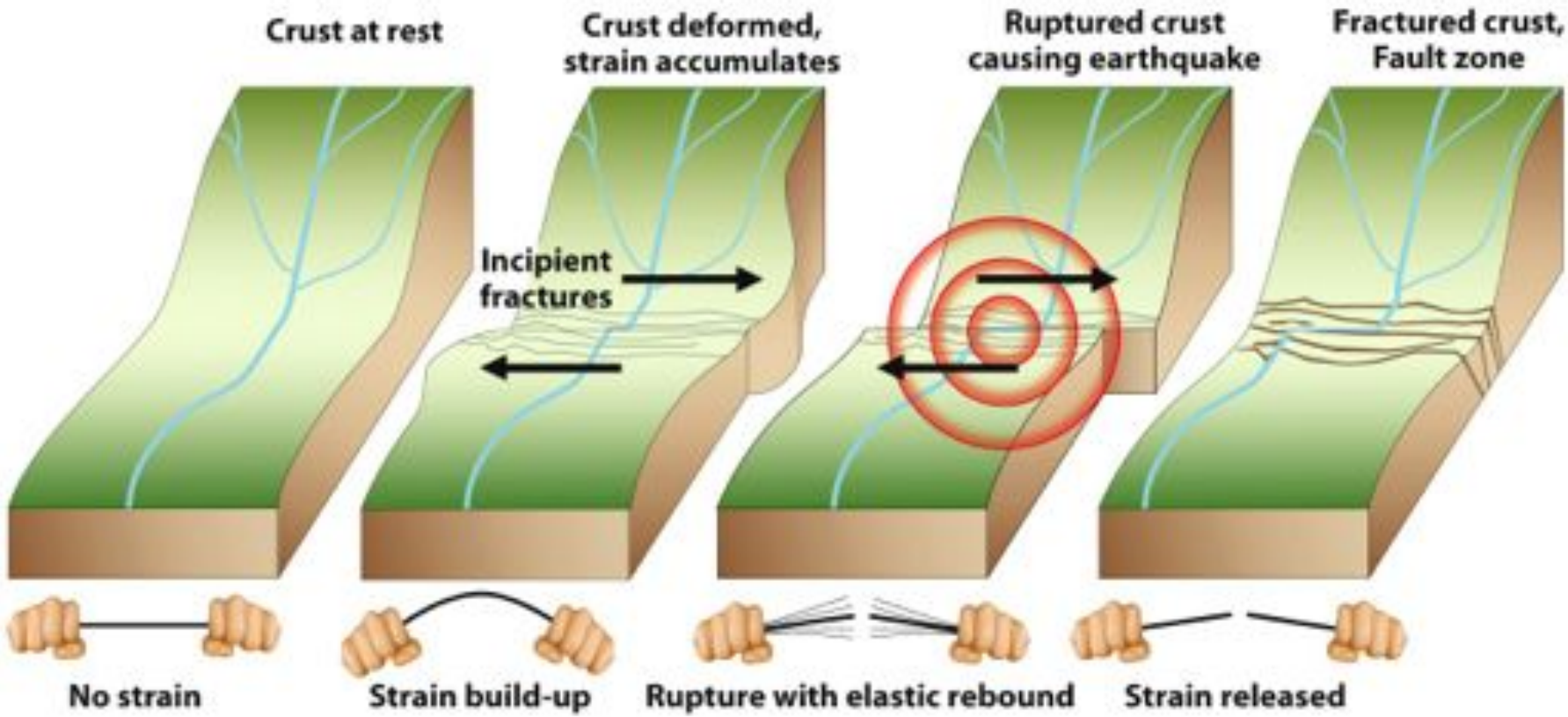
a. Right-lateral
b. Left-lateral

iClicker Question

What type of strike-slip fault is this?

a. Right-lateral
b. Left-lateral

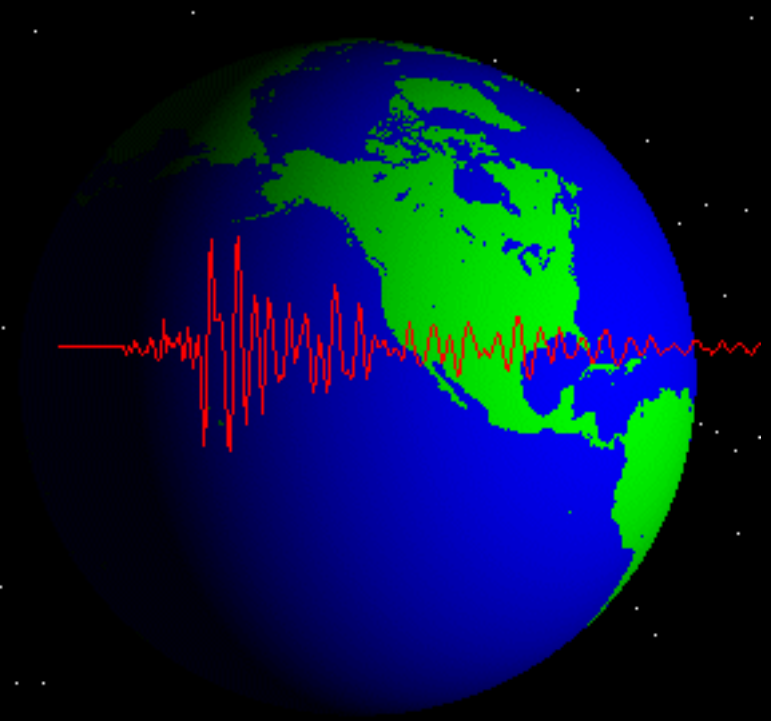
What Are Earthquakes?



Earthquakes result from slow buildup of elastic strain, and its sudden release – like bending a ruler until it breaks.

Elastic Rebound Theory

Learning Objectives (LO)



Lecture 15: Earthquakes
Read: Chapter 11

1. Describe different earthquake hazards
2. List 4 types of seismic waves
3. Describe how seismic wave characteristics result in shadow zones

Factors that determine level of destruction

- Proximity (how close)
- Intensity of quake
- Duration of quake
- Building design
- Nature of the ground (rocks)

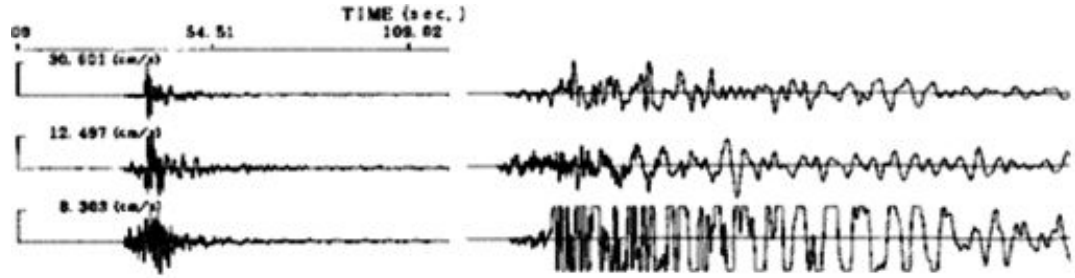
LA mountains, 1994

Oakland, 1989

Liquefaction

- Strong shaking will cause wet soil to behave **temporarily** like a liquid, not a solid

Kobe, Japan Earthquake



hard rock wet, soft soil

- Places where liquefaction is a serious hazard:
  - Marina District (San Francisco)
  - LA basin
  - Mexico City
  - Kobe, Japan

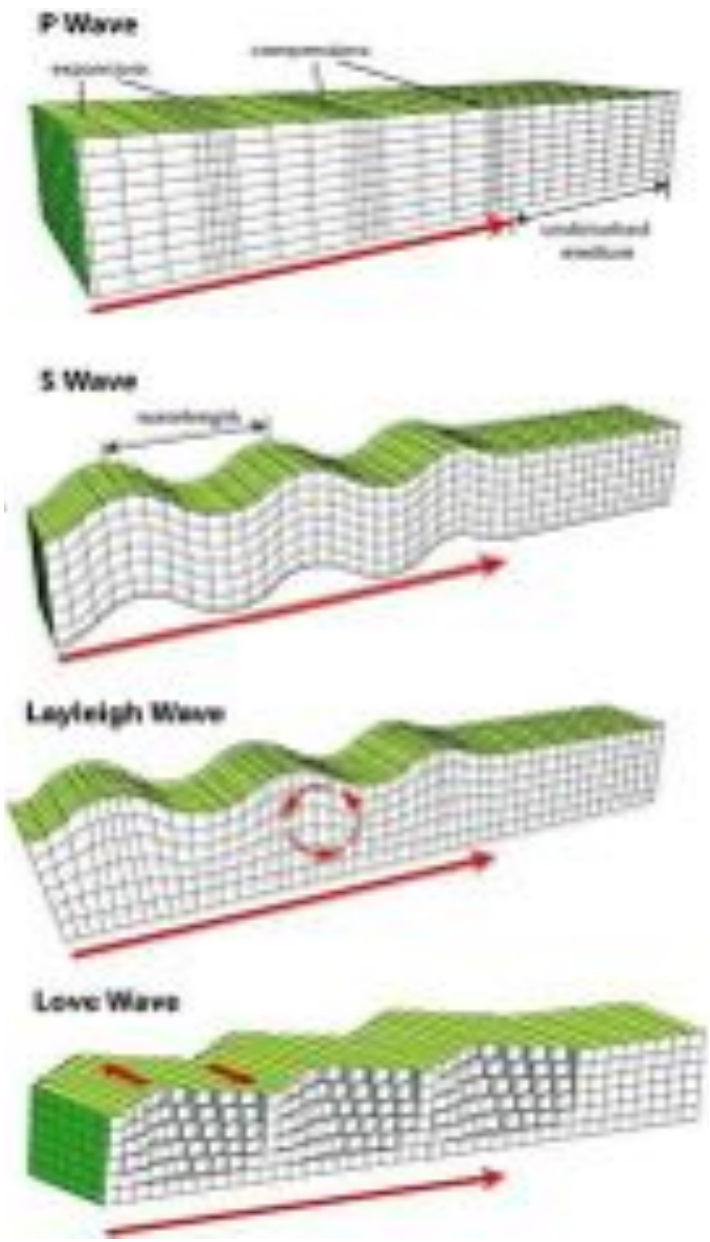
Two Types of Seismic Waves

1. **Body Waves:** travel through the body of the Earth (P & S)

- Waves compress and pull rocks in the direction of movement,
- Change the **volume** & **shape** of material

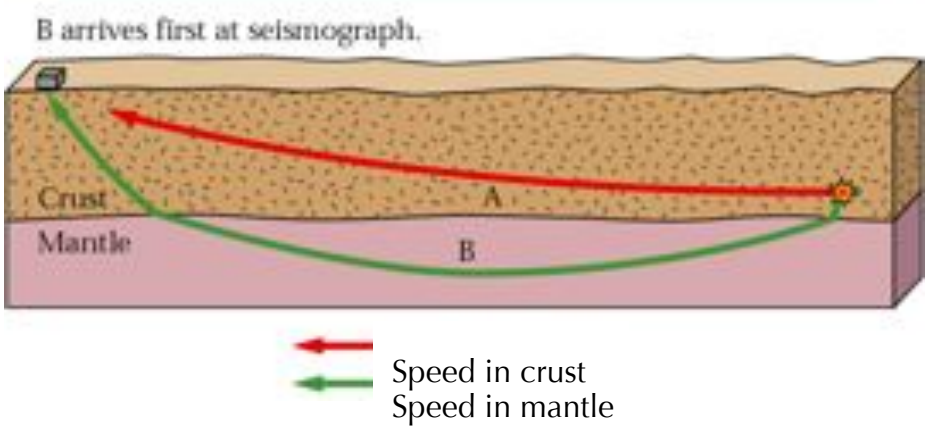
2. **Surface Waves:** travel along the outer layer of the crust (Love and Raleigh)

- Ground rolls like a water wave
- Waves travel slowly and cause the most damage.



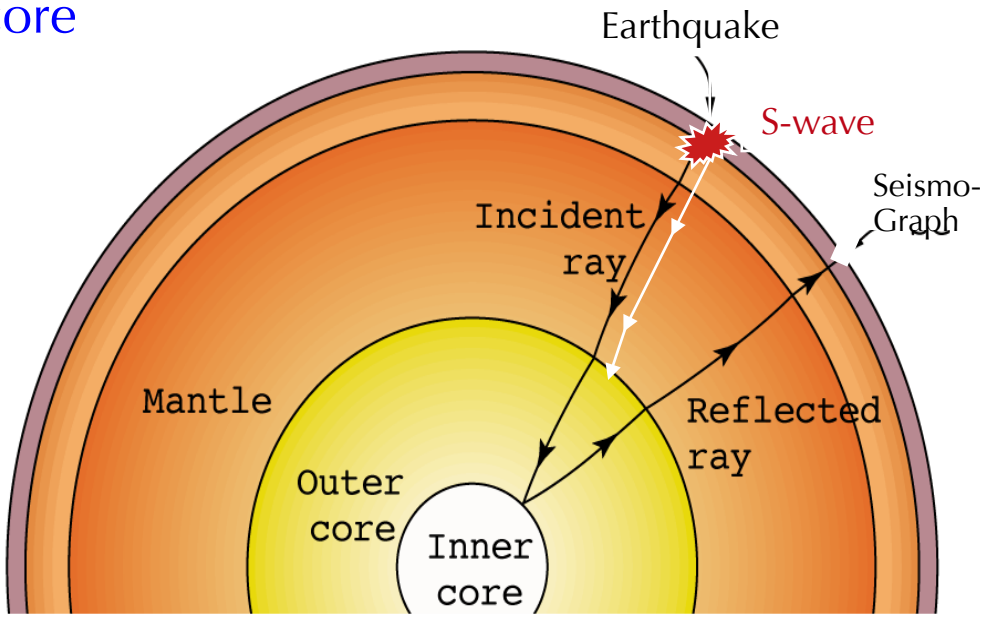
Discoveries about Earth's Interior

- **Crust-Mantle Boundary**
  P and S waves travel **faster** in the mantle: **more dense**

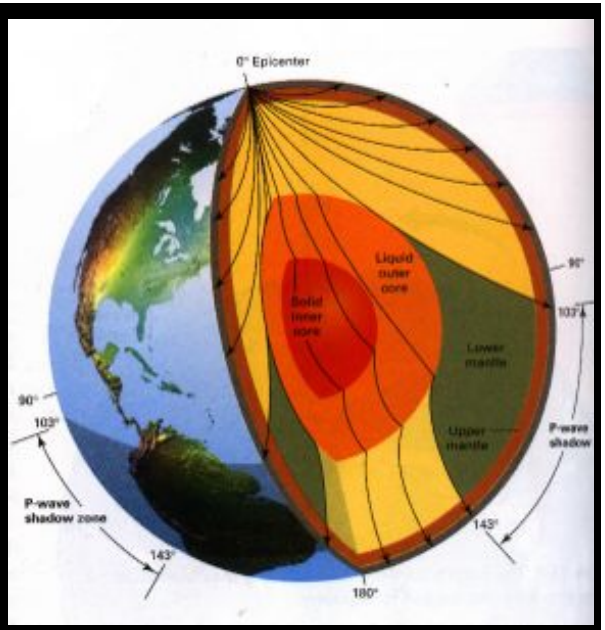


- **Liquid outer core**
  S waves can't travel through liquid core

- **Solid inner core**
  P waves reflect off of solid inner core



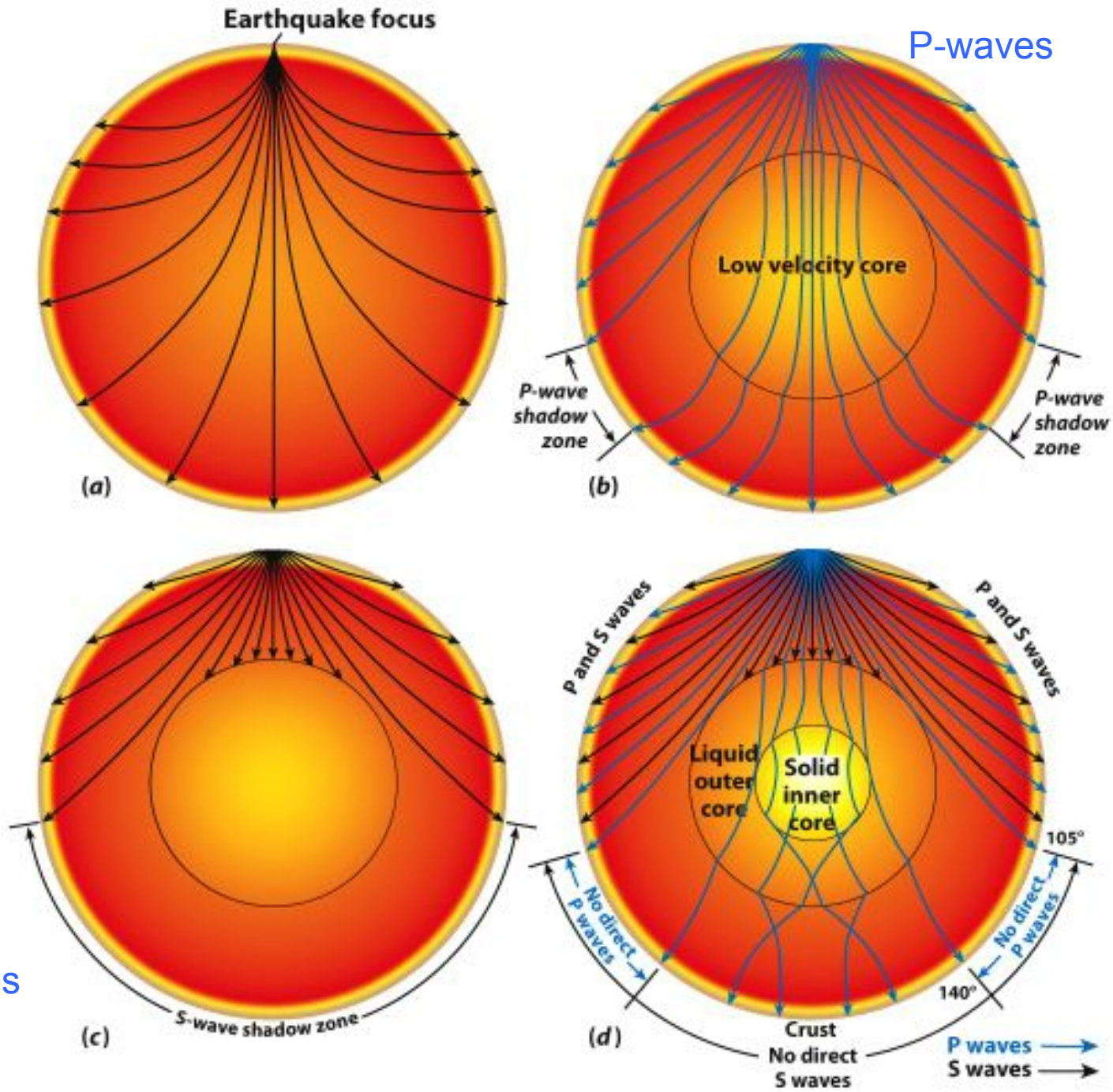
iClicker Question



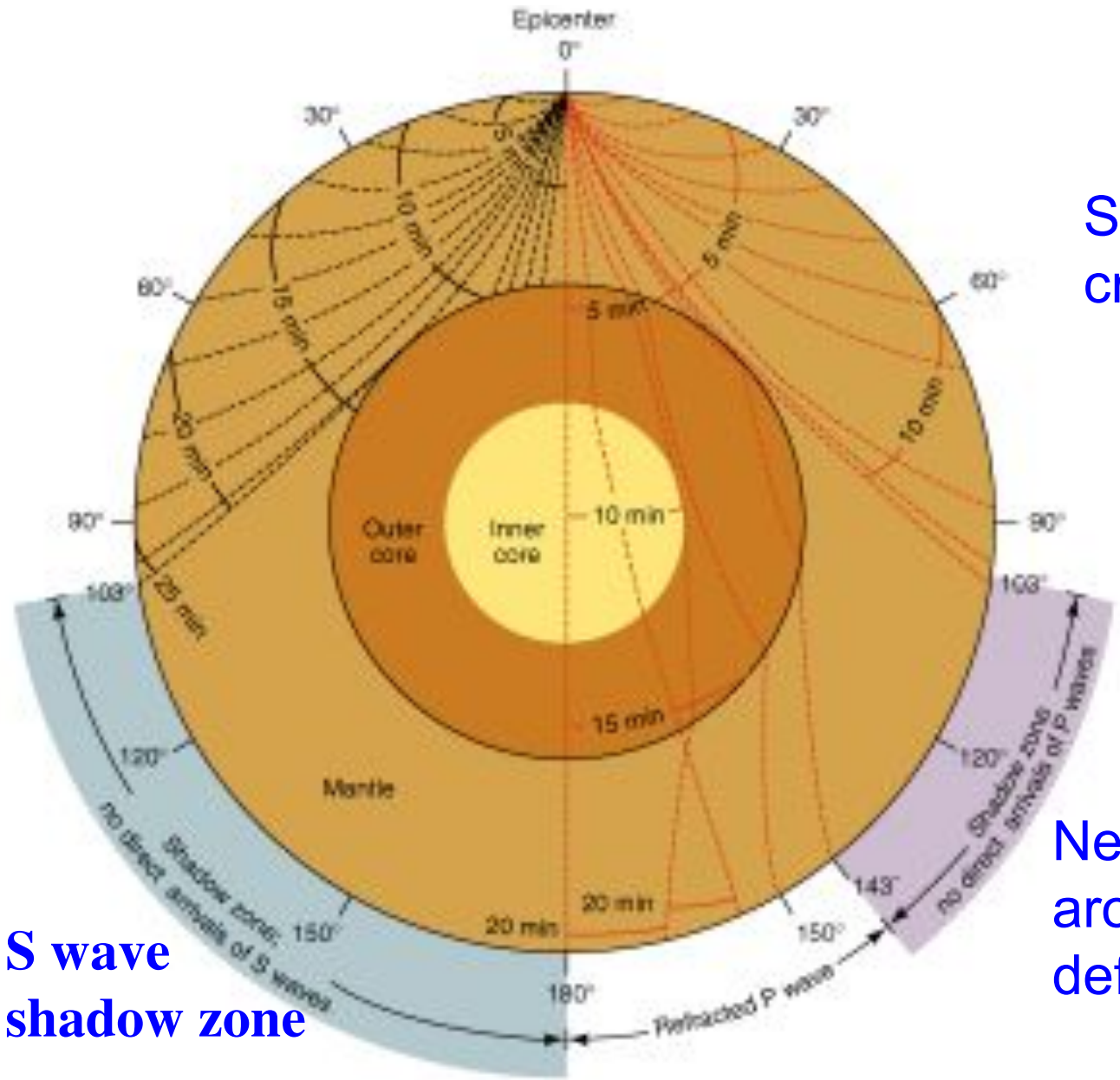
Seismic shadow zones are the result of:

a. Waves absorbed in the liquid outer core
b. A lack of large earthquakes
c. A lack of seismometers in the Southern Hemisphere

Traveling S- and P-waves through the Earth.



Seismic Shadow Zones



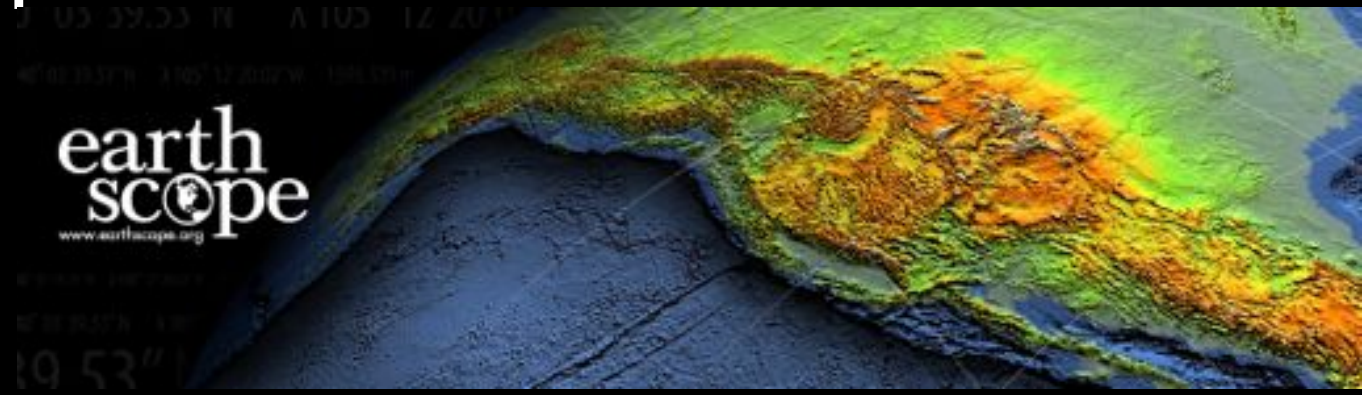
S-wave propagation creates a shadow zone

Network of epicenters around Earth's surface defines the interior zones

S wave shadow zone

Learning Objectives (LO)

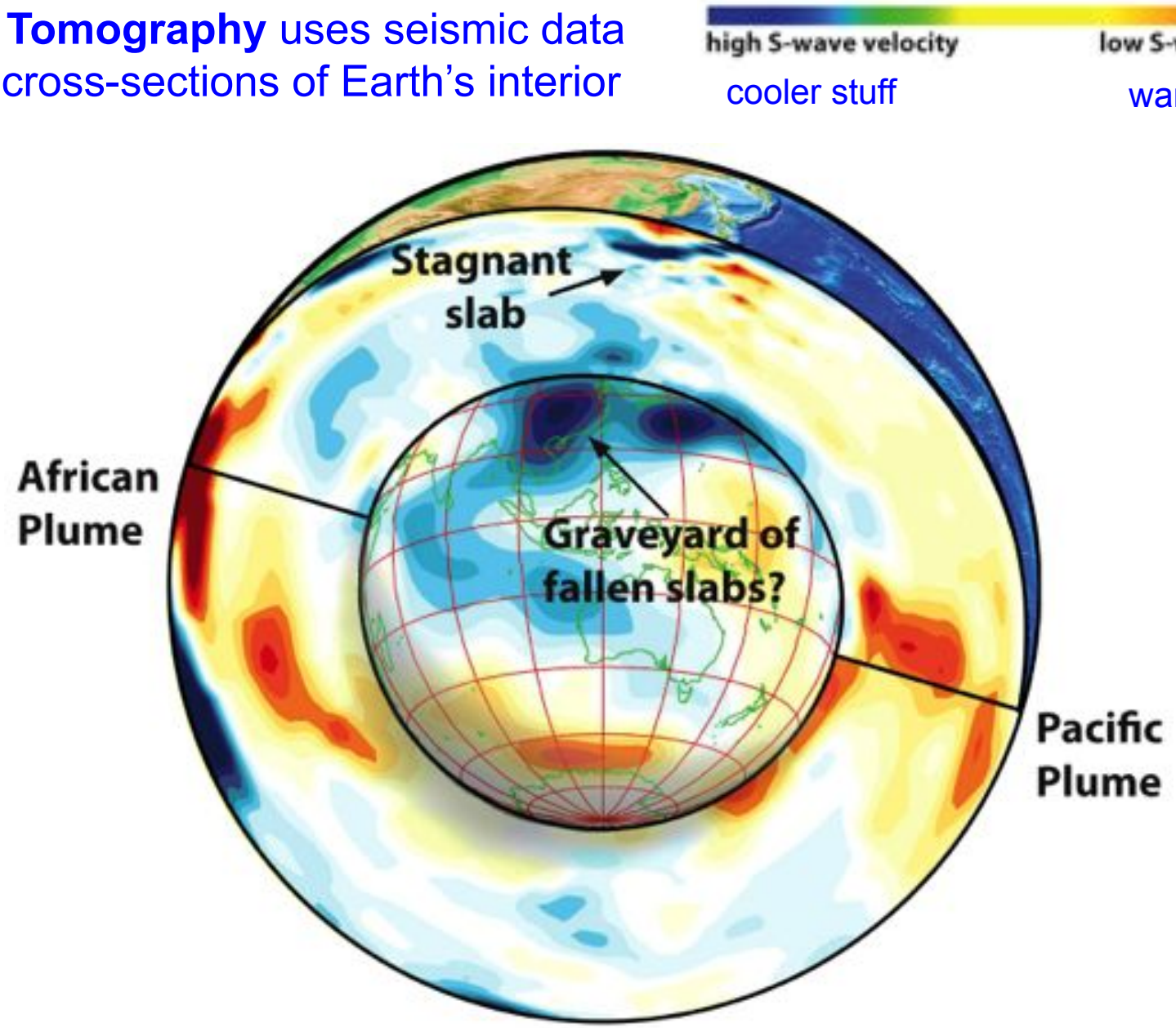
Lecture 16: EarthScope and Tsunamis
Read: Chapter 11



1. EarthScope Project (National Science Foundation)
2. Seismic tomography and what it reveals about Earth's interior
3. Tsunami generation and hazards

Seismic Tomography

Seismic Tomography uses seismic data to make cross-sections of Earth's interior



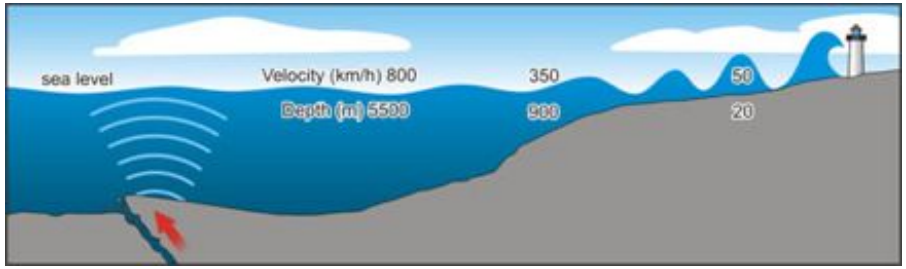
Tsunamis

Tsunamis are NOT tidal waves

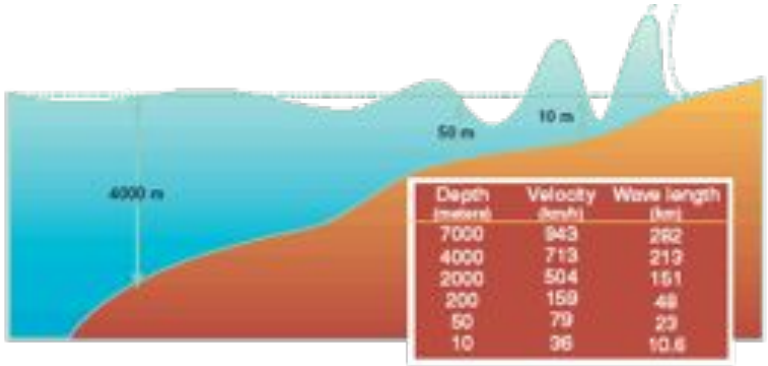
1.

Tsunamis are seismic sea waves caused by earthquakes, landslides, eruptions of island volcanoes.

2.

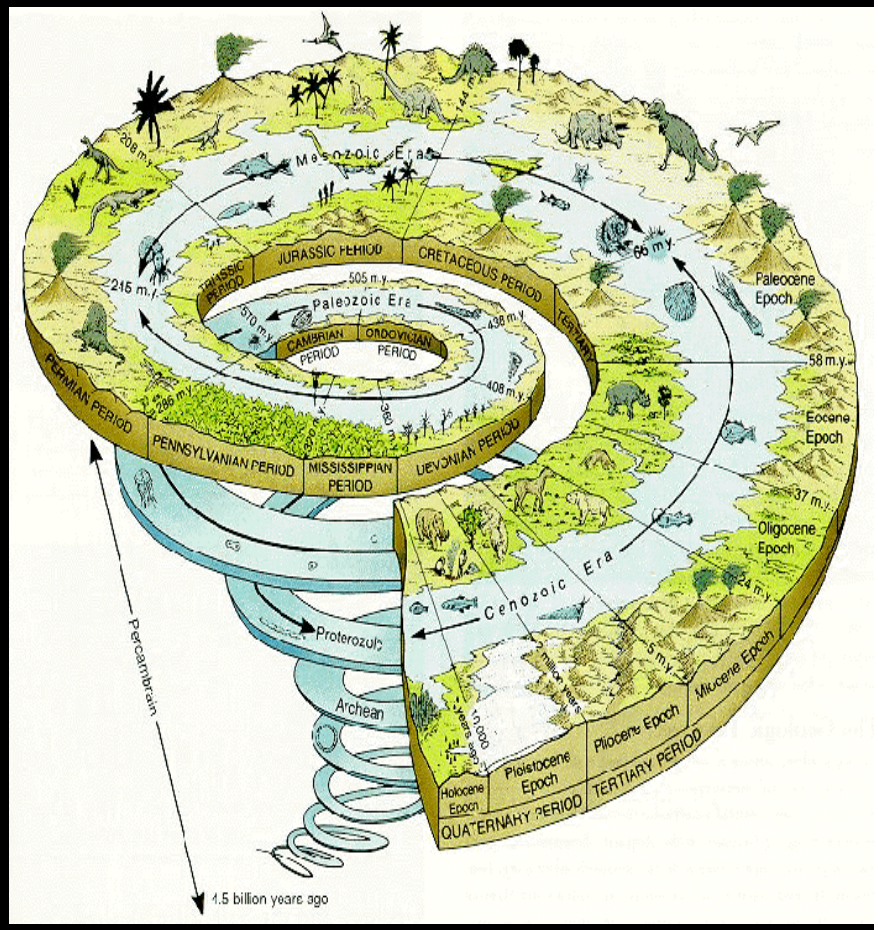


3.



Learning Objectives (LO)

Lecture 17: Age Dating and Earth History
Read: Chapter 12-13

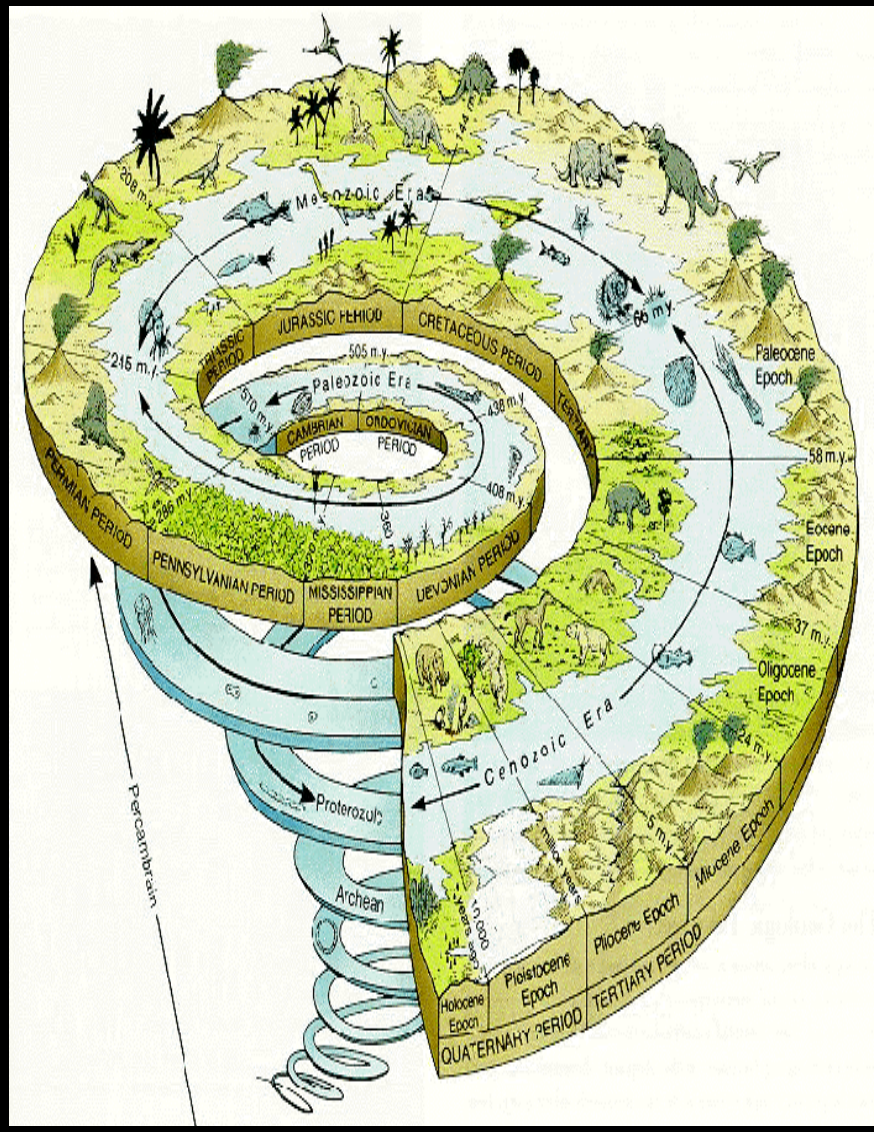


1. Define the concept of half-life and absolute age dating
2. List the major extinctions and when they occurred
3. Describe the geologic time scale and how it is organized

iClicker Question

If you could travel back in time to when the Earth first formed as a planet, approximately how many years back in time would you have to travel?

A. 4 hundred years
B. 4 hundred thousand years
C. 4 million years
D. 4 billion years
E. 4 trillion years



How old is that rock?

- Relative age: order of events

  Relative dating tells us <u>what order</u> things happened, but not how many years ago they happened.

- Absolute age: age in years

iClicker Question

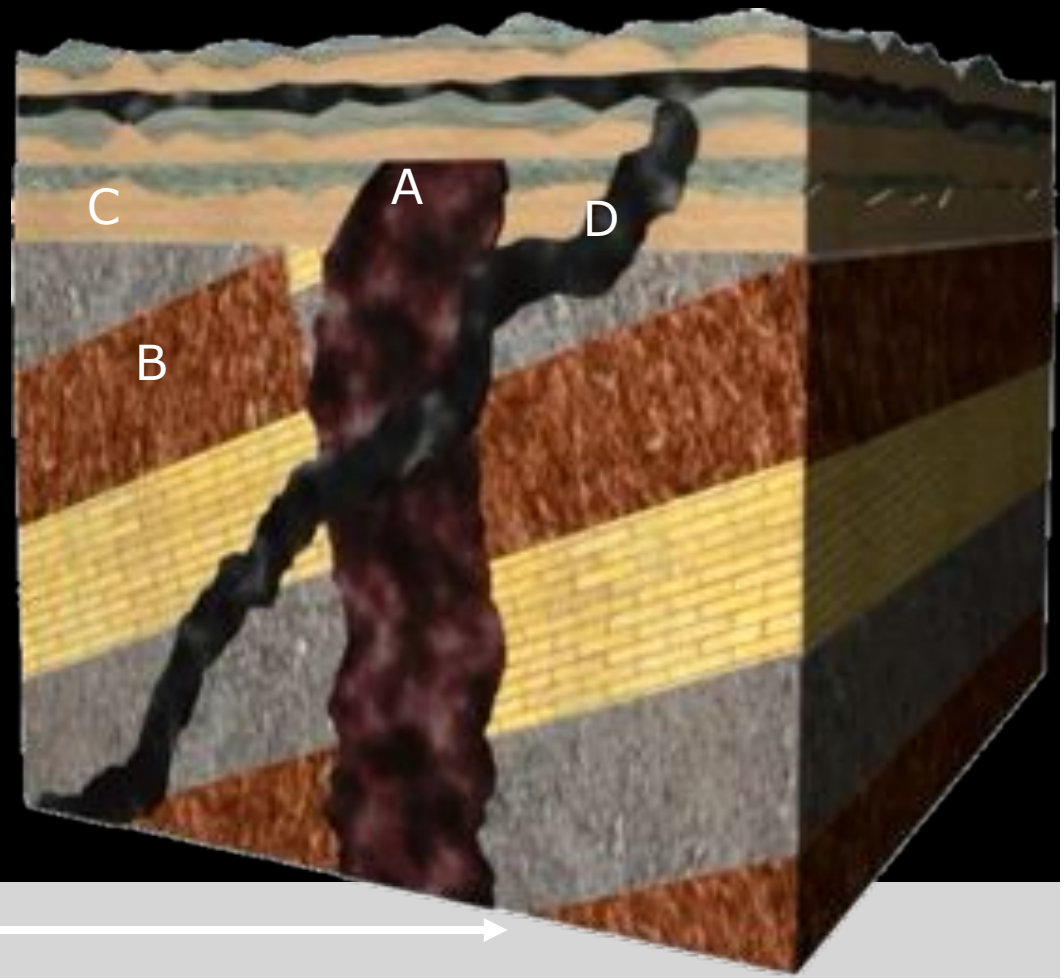
In this figure which layer is youngest?:

A

B

C

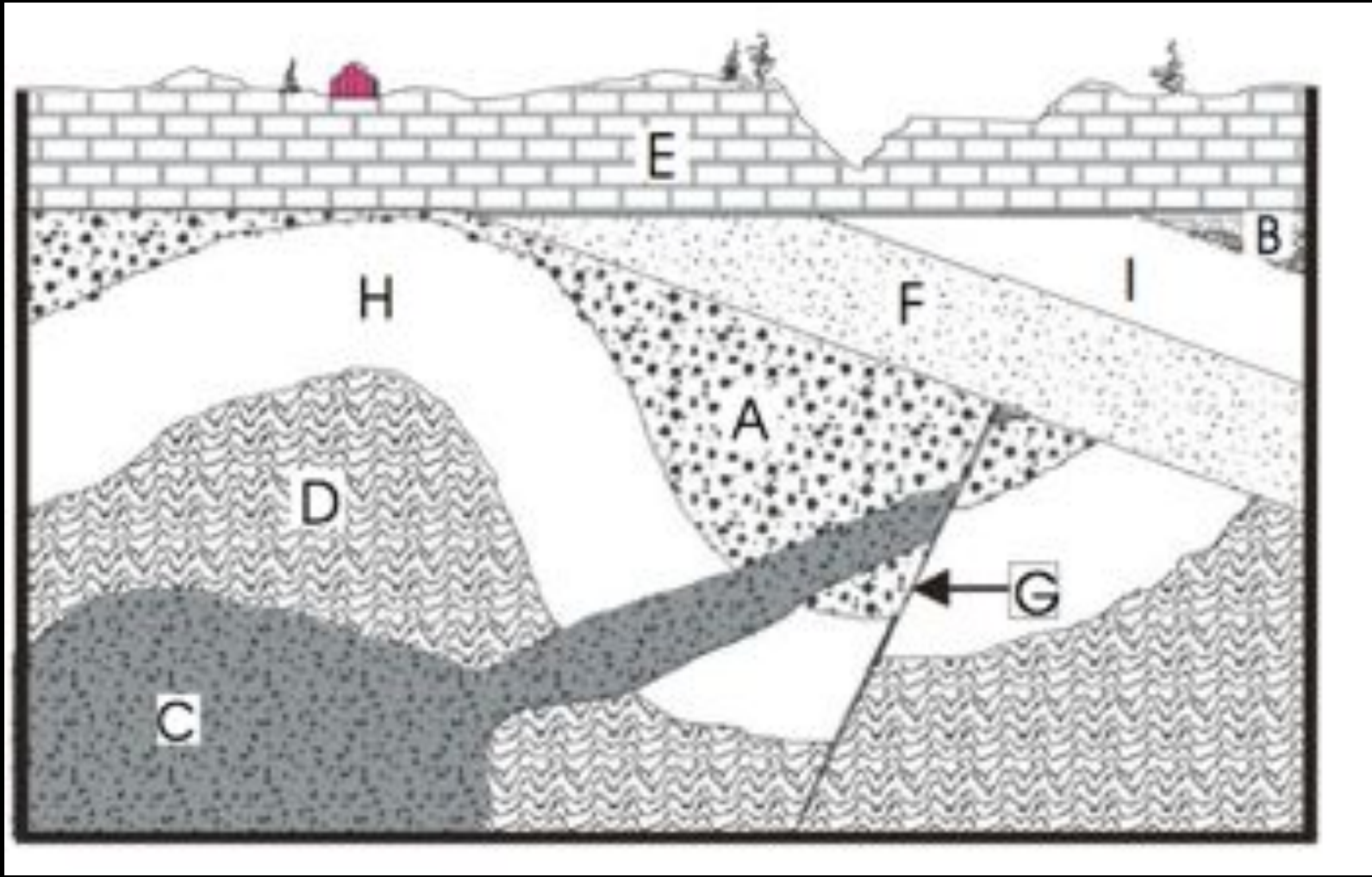
D



Go to Visualization →

iClicker Question

Which best describes the geologic history of events?



a. C first, then D, H, A, F, I, B, G, E
b. D first, then H, A, C, G, F, I, B, E

Radioactive Half-Life

- Def.: time it takes for 1/2 of radioactive atoms in a sample to decay

- "Parent" decays to "daughter"
  (potassium-40) (argon-40)

- Potassium-40 half-life
  = 1.3 billion years

iClicker Question

Calculating Absolute Age

- Potassium-40 included in mineral (start clock)
- Begins decaying to Argon-40
- Brilliant scientists have told us the half-life of K-Ar is
- 1.3 billion yrs (Gyr)
- We count # parents & daughters in sample
  - We find that our sample contains 50% K & 50% Ar
  - So 1/2 of our initial sample (K) has decayed
  - How old is it?

A. 650 million years B. 1.3 billion years C. 50 years

1 half-life = 1.3 billion years
1 half-life = 50% of sample decayed to daughter

iClicker Question

Calculating Absolute Age

The half-life of uranium-235 is 700 million years.

If a rock that formed 2100 million years ago originally contained 20 grams of uranium-235, about how much uranium-235 would be left in that rock today?

a. 1 gram
b. 2.5 grams
c. 5 grams
d. 10 grams

2100/700 = 3 half-lives
Divide 20 grams in half *3 times*

→ *20/2 = 10 grams*
10/2 = 5 grams
5/2 = 2.5 grams

Midterm #2 Info

- Midterm info:
  - Midterm exam on Thursday, October 29th
  - 50 multiple choice/true-false questions
  - Covers material from Lectures 9-17
  - 1 hand-written page "cheat sheet" allowed (double-sided ok)
  - Things to help you study:
    1. Lecture notes
    2. Midterm practice exam (posted on web)
    3. Homework
    4. Assigned reading

http://www.soest.hawaii.edu/GG/FACULTY/smithkonter/GG_101/