Do Now:

1. Who was Alfred Wegener?
2. What was Pangaea?
3. Are continents fixed? (Can they move?)
4. What evidence supports the idea that continents have moved over time?

CHAPTER 17
PLATE TECTONICS

Objectives

- What evidence suggests that continents move?
- Why was the theory of continental drift not supported?
- What is seafloor spreading? How does it explain continental drift?
- What are tectonic plates and what occurs near plate boundaries?

Vocabulary:

- Continental Drift
- Pangea
- Magnetometer
- Magnetic reversal
- Paleomagnetism
- Isochron
- Seafloor spreading

Vocabulary:

- Tectonic plate
- Divergent boundary
- Rift valley
- Convergent boundary
- Subduction
- Transform boundary (strike-slip)
- Ridge push
- Slab pull

Section 17.1: Drifting Continents

- Identify the lines of evidence that led Wegener to suggest that Earth's continents have moved.
- Discuss how evidence of ancient climates supported continental drift
- Explain why continental drift was not accepted when it was first proposed.

TIME SCALES:

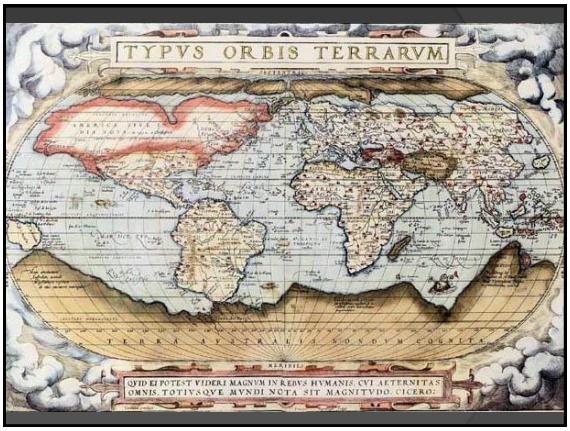
- What are some examples of time scales that we often use?
- Because of the immense age of the Earth, **geologic time scales** are in thousands, millions, and billions of years.

Early Observations

- **Most of Earth's Surface appears to remain unchanged during the course of our lifetime, with exception to events such as earthquakes, volcanic eruptions, and landslides.**
- **On the geologic time scale, Earth's surface has changed dramatically.**

Early Observations

- **Cartographers were some of the first people to suggest that Earth's surface has dramatically changed with time.**
- **In the late 1500s, Abraham Ortelius noticed the apparent fit of the continents on either side of the Atlantic Ocean**



Early Observations

- **Over the next 300 years, many scientists and writers noticed and commented on the matching coastlines.**

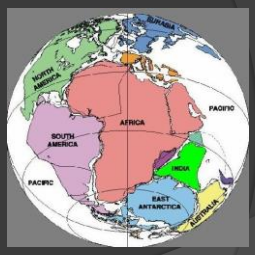
Antonio Snider-Pelligrini
1858

Early Observations

- **The first time that the idea of moving continents was proposed as a scientific hypothesis was in the early 1900's.**
- **In 1912, German scientist Alfred Wegener presented his ideas about continental movement to the scientific community.**

Early Observations

Alfred Wegener

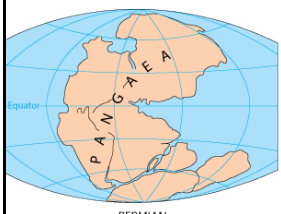


Continental Drift

- Wegener developed an idea that he called **continental drift**.
- Continental drift proposes that Earth's continents had once been joined as a single land mass that broke apart and sent the continents adrift.

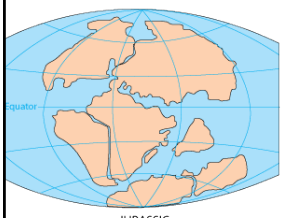
Continental Drift

- Wegener called the original supercontinent **Pangaea.**
- **Pangaea** [from Greek, literally: all-earth]
- Pangaea began to break apart about 200 mya. Since that time, the continents have continued to slowly move to their present positions.

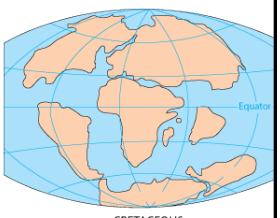


PERMIAN
250 million years ago

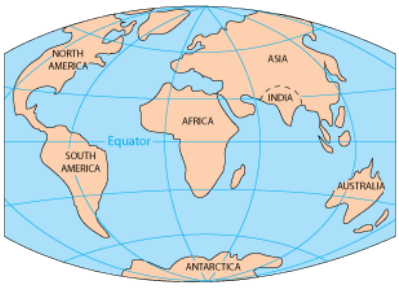
TRIASSIC
200 million years ago



JURASSIC
145 million years ago



CRETACEOUS
65 million years ago



PRESENT DAY

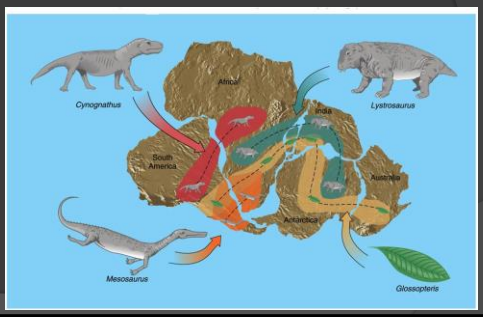
Evidence from Rock Formation

- Wegener reasoned that when Pangaea broke apart, large geologic structures fractured as the continents separated.
- Rock layers in the Appalachian Mountains were identical to mountains in Greenland and Europe.

Evidence from Fossils

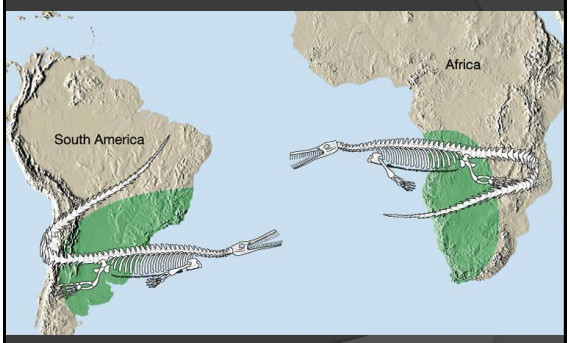
- Wegener also gathered evidence of continental drift from fossils.
- Similar fossils predating the separation of Pangaea had been found on widely separated continents.

Evidence from Rock Formation



Evidence from Fossils

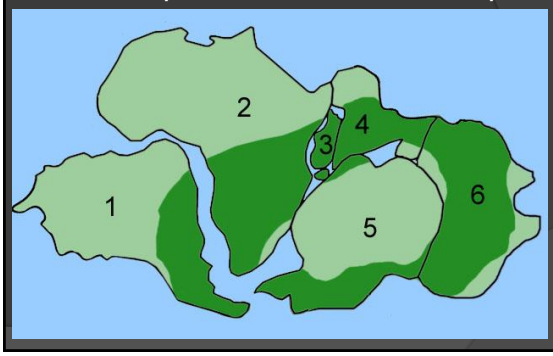
- Wegener argued that because fossils of mesosaurus, an aquatic reptile, had been found in only freshwater, it was unlikely that it could have crossed the oceans.
- These fossils were also older than 200 mys.



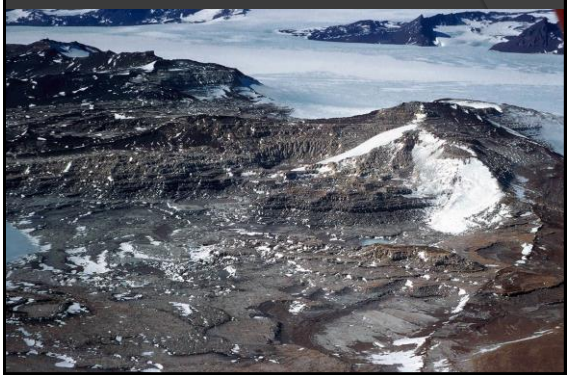
Climatic Evidence

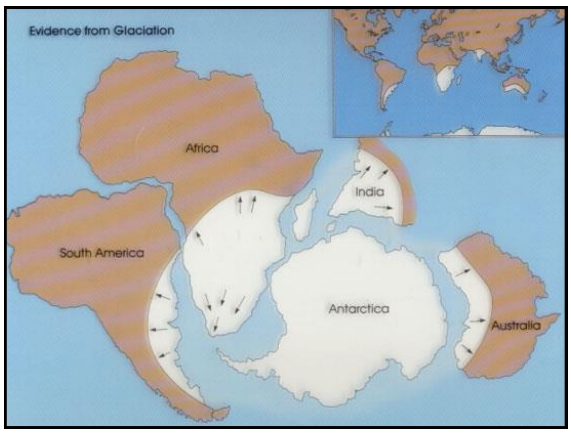
- Because of his strong background in meteorology, Wegener recognized clues about ancient climates from the fossils he studied.
- *Glossopteris* fossil
- Coal in Antarctica
- Glacial Deposits

Glossopteris distribution map



Coal in Antarctica





Distance between the Atlantic

- The distance from South America to Africa is roughly 1600 miles.
- If these continents move apart at a rate of .5 inches per year, how many years would it have taken for them to get to where they are?

Distance between the Atlantic

$$\frac{1600 miles}{1} x \frac{5280\ ft}{1\ mile} x \frac{12\ inches}{1\ ft}$$

= 101 376 000 inches

Distance between the Atlantic

$$\frac{101\ 376\ 000\ in}{.5\ in/year}$$

= 202 752 000 years

Continental Drift: Rejected

- Continental drift had two major flaws that prevented it from being widely accepted.

1. It did not explain what force could be strong enough to push massive continents over great distances.
2. Earth's mantle under the crust was solid. How did continents move through something solid?

Section 17.2: Seafloor Spreading

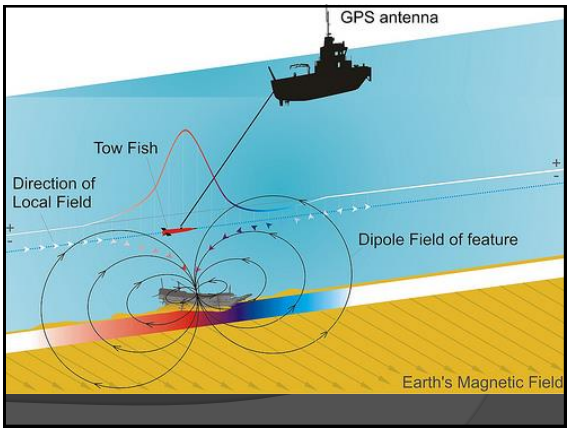
- **Objectives:**
- Summarize the evidence that led to the discovery of seafloor spreading.
- Explain the significance of magnetic patterns on the seafloor.
- Explain the process of seafloor spreading.

Mapping the Ocean Floor

- Until the 1900s, most people, including scientists thought that the ocean floor was essentially flat and unchanging.
- Advances in technology during the 1940s and 1950s showed that these widely accepted ideas were incorrect.

Mapping the Ocean Floor

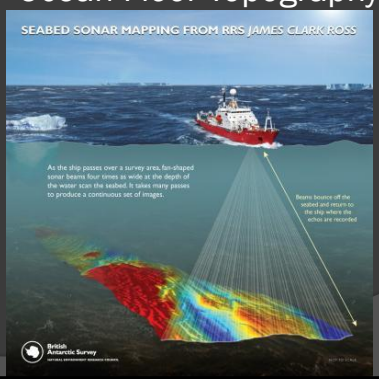
- One technological advance that was used to study the ocean floor was the magnetometer.
- A magnetometer is a device that can detect small changes in magnetic fields.



Mapping the Ocean Floor

- Another advancement that allowed scientists to study the ocean floor in great detail was the development of **sonar**.
- Developments in sonar technology enabled scientists to measure water depth and map the topography of the ocean floor.

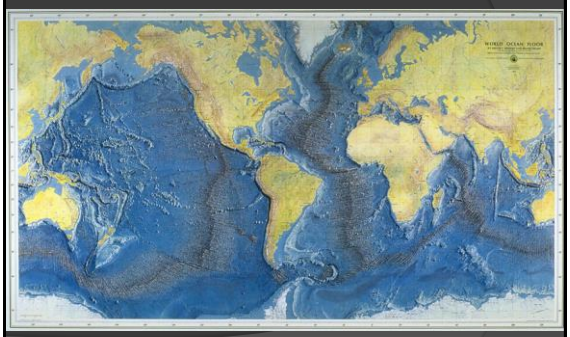
Ocean Floor Topography

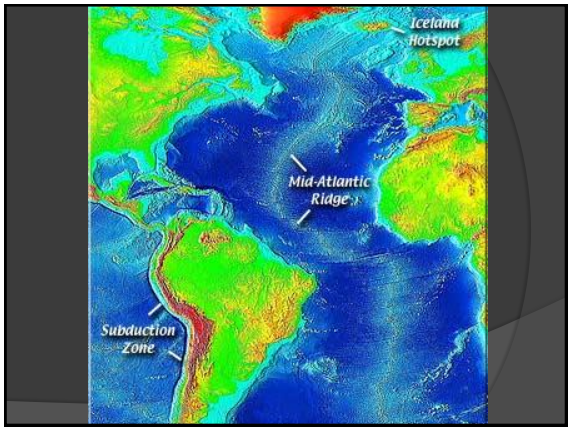


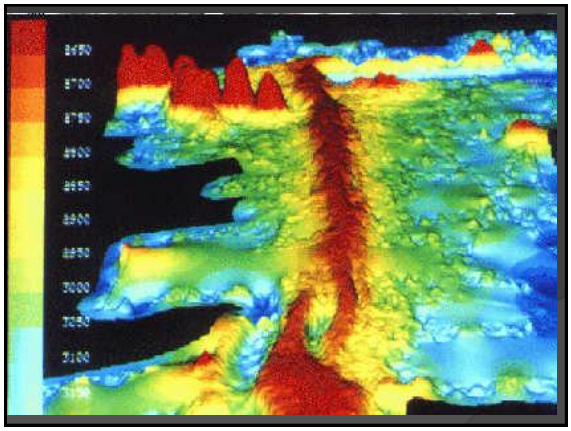
Ocean Floor Topography

- The maps made from data collected by sonar and magnetometers surprised scientists.
- They discovered the vast, underwater mountain chains called **ocean ridges** run along the ocean floors. They form the longest continuous mountain range on Earth.

Ocean Ridges







Ocean Ridges

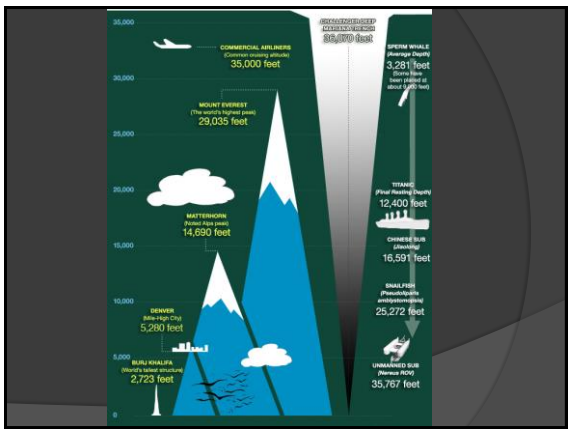
- Ocean ridges generated much discussion when they were first discovered because of their enormous length and height.
- They are more than 80,000km long and 3km above the ocean floor.
- **50,000 miles long, 2 miles high.**

Deep-Sea Trenches

- Maps generated with sonar also revealed that underwater mountain chains had counterparts called **deep-sea trenches.**
- A deep-sea trench is a narrow, elongated depression in the sea floor.

Deep-Sea Trenches

- The deepest trench, called the Marianas Trench, is in the Pacific Ocean and is more than 11 km deep (7 miles).
- Mount Everest, the tallest mountain on land, could fit inside the Marianas Trench with 6 empire state buildings stacked on top.



Ocean Floor Topography

- Ocean ridges and deep-sea trenches puzzled geologists for more than a decade after their discovery.
- They did not know what could have formed these mountains and trenches 6 times deeper than the Grand Canyon

Ocean Rocks and Sediments

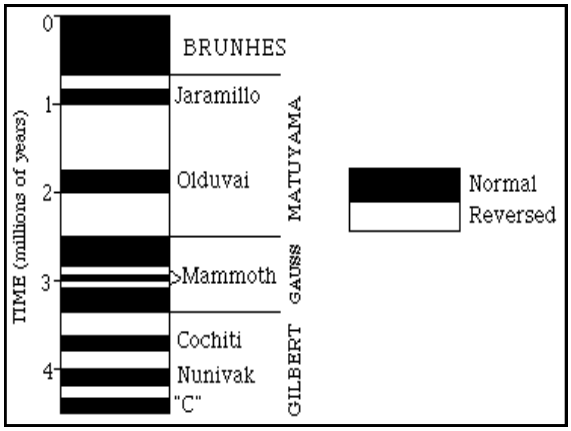
- Scientists collected samples of deep-sea sediments and the oceanic crust.
- They discovered that the age of these rocks consistently increases with distance from ocean ridges.
- Thickness of ocean sediments increase in depth away from ocean ridges.

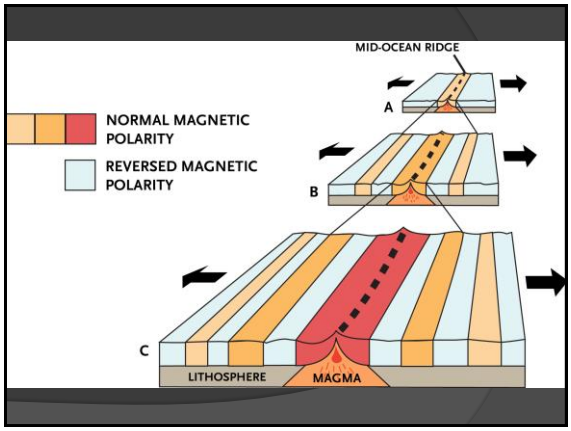
Magnetism

- A **magnetic reversal** happens when the flow in the outer core changes, and Earth's magnetic field changes direction.
- Magnetic reversals have occurred many times in Earth's History.

Magnetism

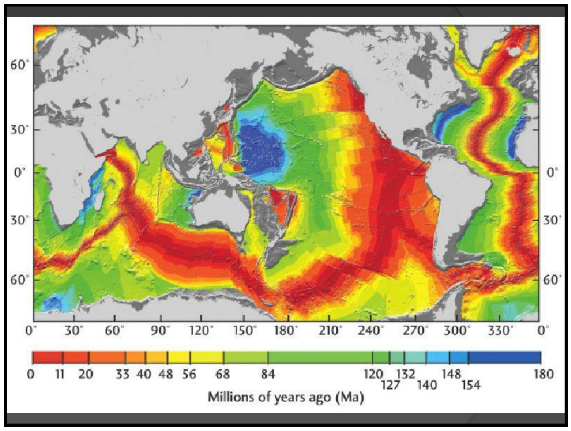
- **Paleomagnetism** is the study of the history of Earth's magnetic field.
- When lava solidifies, iron minerals behave like compasses and form crystals which align with Earth's magnetic field.

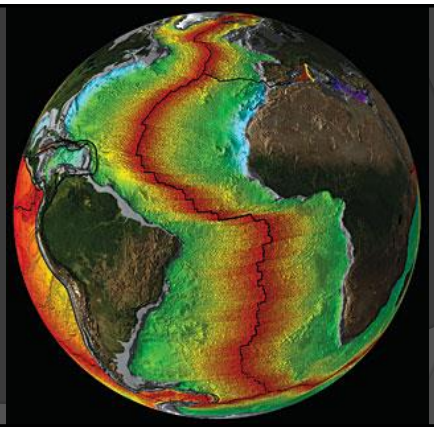




Magnetism

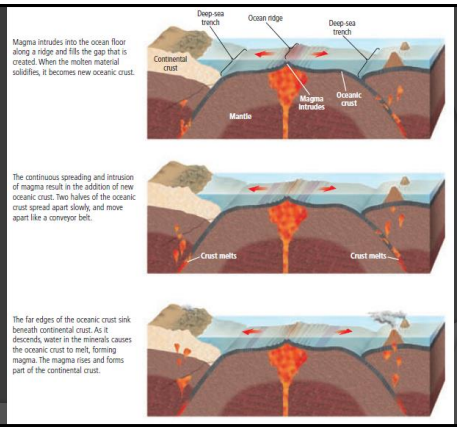
- Data gathered from paleomagnetic studies quickly enabled scientists to create isochron maps of the ocean floor.
- An isochron is an imaginary line on a map that shows points of the same age.

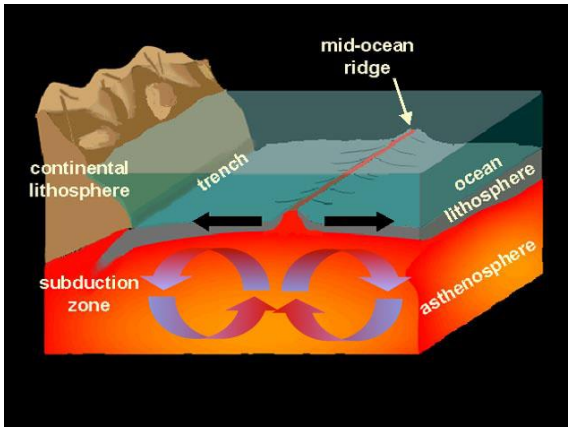




Seafloor Spreading

- Seafloor spreading is the theory that explains how new ocean crust is formed at ocean ridges and destroyed at deep-sea trenches.





Section 17.3: Plate Boundaries

- Objectives:
- Describe how Earth's tectonic plates result in many geologic features.
- Compare and contrast the three types of plate boundaries and the features associated with each.
- Generalize the processes associated with subduction zones.

Plate Boundaries:

Main Idea:

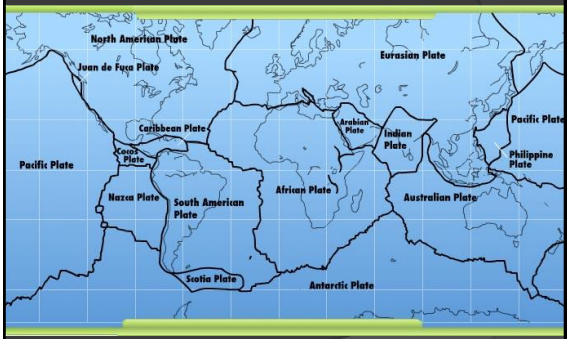
- **Volcanoes, mountains, and deep-sea trenches form at the boundaries between the plates.**

Theory of Plate Tectonics:

The evidence of seafloor spreading suggested that continental and oceanic crust moves as enormous slabs, which geologists describe as tectonic plates.

Theory of Plate Tectonics:

- **Tectonic plates** are huge pieces of crust and rigid upper mantle that fit together at their edges to cover Earth's surface.
- There are about **12** major plates and several smaller plates.



Theory of Plate Tectonics:

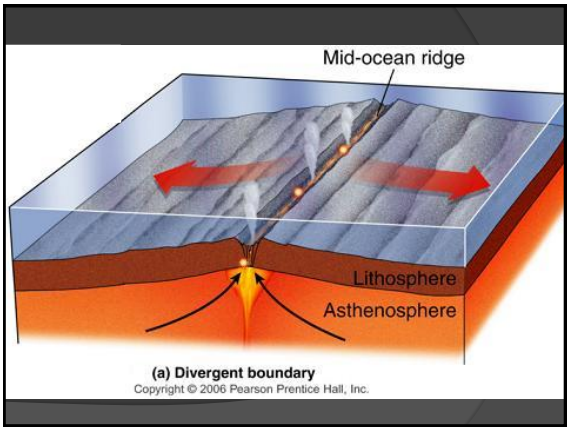
- Tectonic plates move very slowly – only a few centimeters a year on average.
- They move in different directions and at different rates relative to one another.
- They interact at **plate boundaries**.

Plate Boundaries:

- There are three main types of plate boundaries:
- Divergent boundaries
- Convergent boundaries
- Transform boundaries.

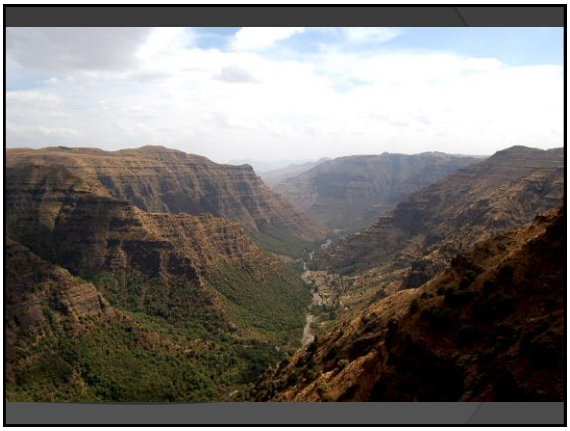
Divergent Boundaries:

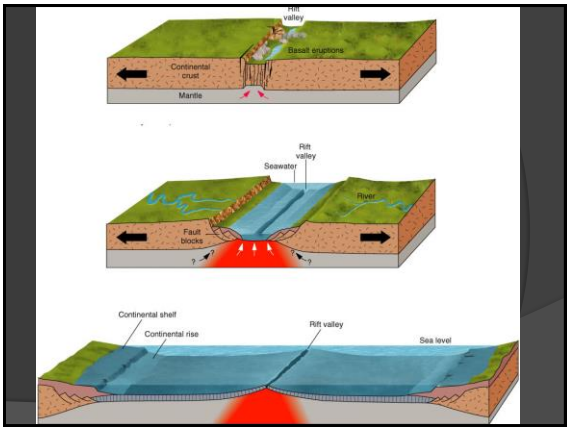
- Regions where two tectonic plates are moving apart are called **divergent boundaries**.
- Most divergent boundaries are found along the seafloor in ocean ridges.

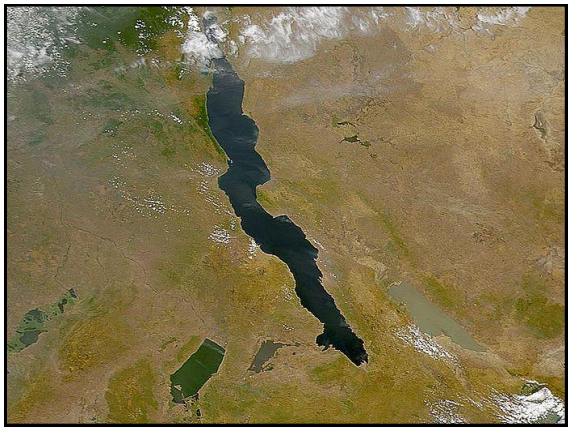


Divergent Boundaries:

- Most divergent boundaries form ridges on the ocean floor, however, when continental crust begins to separate, the stretched crust forms a long, narrow depression, called a **rift valley.**







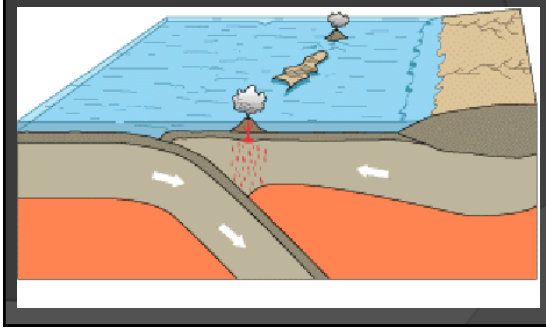
Convergent Boundaries:

- At convergent boundaries, two tectonic plates are moving toward each other.
- When they collide, the denser plate eventually descends below the other, less-dense plate in a process called **subduction.**

Convergent Boundaries:

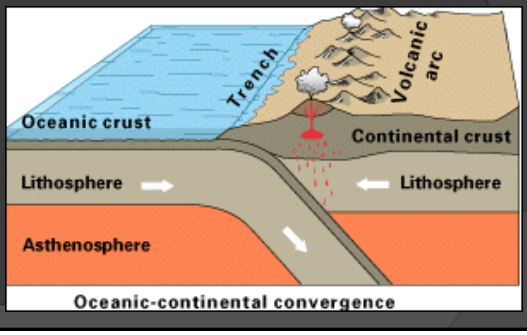
- There are three main types of convergent boundaries:
- **Oceanic-oceanic**
- **Oceanic-continental**
- **Continental-continental**

Oceanic-oceanic:

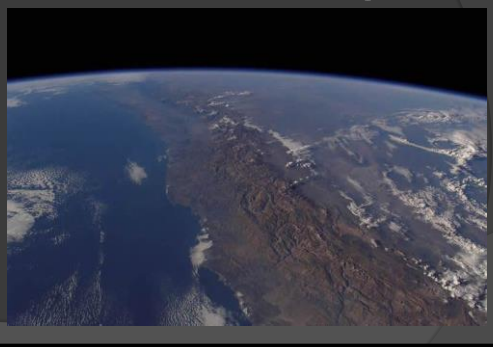


Aleutian Islands:

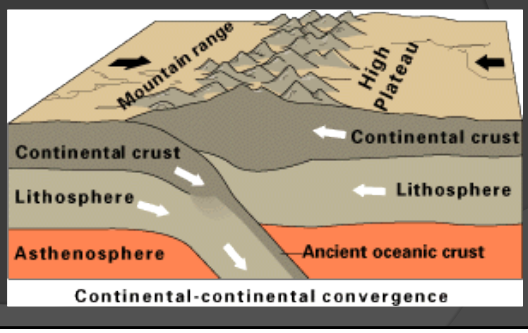
Oceanic-continental:



Andes mountain range:



Continental-continental:

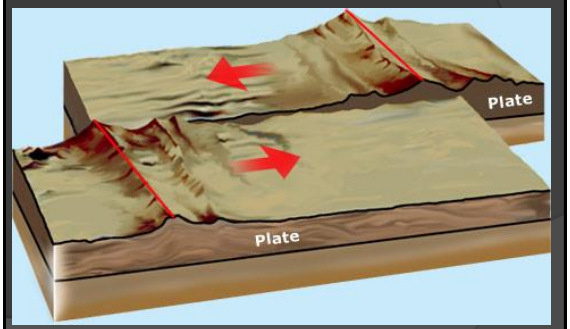


Himalayas:

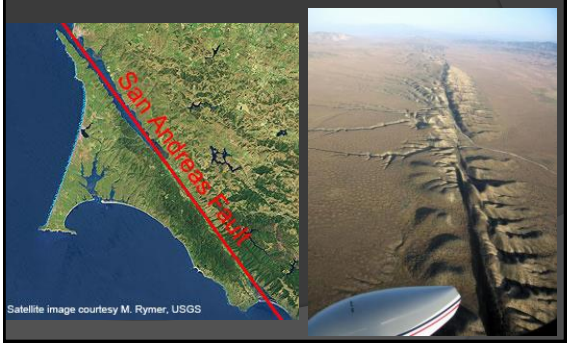
Transform Boundaries:

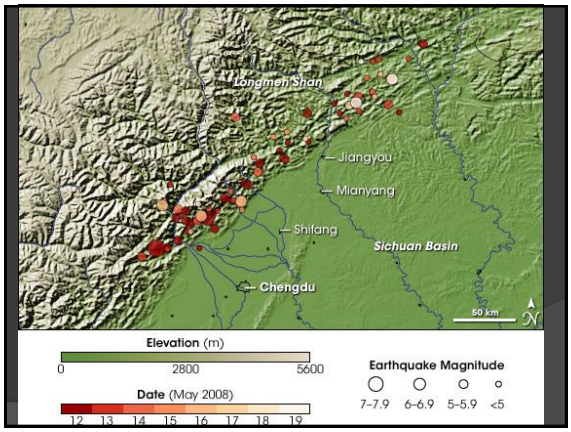
- A region where two plates slide horizontally past each other is called a **transform boundary,** also known as a strike-slip.
- Characterized by long faults and shallow earthquakes.
- Crust is only deformed or fractured along these faults.

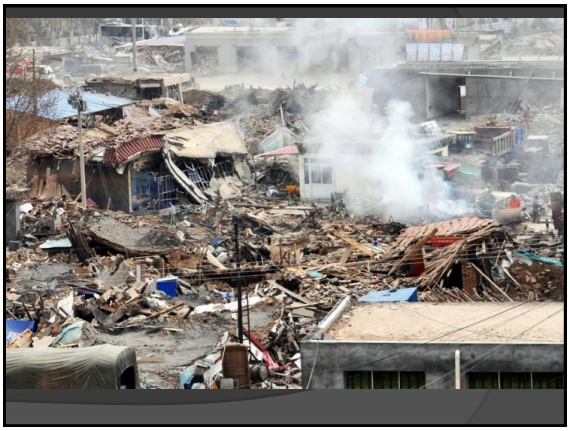
Transform Boundaries:



San Andreas Fault:







Today:

- Complete Chapter 17 Test Review
  (Due Tomorrow)
- Online practice tests and vocabulary review available on MyBigCampus

Practice Questions

This is a device that can detect changes in the strength of the magnetic field:

A. GPS
B. Sonar
C. Magnetometer
D. Satellite

Practice Questions

This is a device that can detect changes in the strength of the magnetic field:

A. GPS
B. Sonar
C. **Magnetometer**
D. Satellite

Practice Questions

Places where two tectonic plates are moving away from each other are called _____.

A. convergent boundaries
B. divergent boundaries
C. earthquake boundaries
D. transform boundaries

Practice Questions

Places where two tectonic plates are moving away from each other are called _____.

A. convergent boundaries
B. **divergent boundaries**
C. earthquake boundaries
D. transform boundaries

Practice Questions

The thickness of ocean sediments that are close to a mid-ocean ridge is _____ the thickness of ocean sediments that are far from mid-ocean ridges.

A. more than
B. the same as
C. always 100 times
D. less than

Practice Questions

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A. more than
B. the same as
C. always 100 times
D. **less than**

Practice Questions

What evidence did Wegener use to estimate the time of Pangaea's break up?

A. Magnetic isochrons
B. Coal deposits
C. Ocean-floor topography
D. Fossil data

Practice Questions

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A. Magnetic isochrons
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D. **Fossil data**

Practice Questions

What is the name of Alfred Wegener's hypothesis about moving landmasses?

A. Continental movement
B. Plate tectonics
C. Continental drift
D. Seafloor spreading

Practice Questions

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Practice Questions

When a divergent plate boundary forms on continents, a _____ forms.

A. Crater
B. Volcano
C. Mid-continent ridge
D. Rift valley

Practice Questions

When a divergent plate boundary forms on continents, a _____ forms.

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Practice Questions

Which type of information was **NOT** collected by Wegener to support his continental drift hypothesis?

A. Fossils
B. Seafloor magnetic data
C. Rocks
D. Glacial deposits

Practice Questions

Which type of information was **NOT** collected by Wegener to support his continental drift hypothesis?

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D. Glacial deposits

Practice Questions

What evidence did Wegener use to suggest that Antarctica had once been closer to the equator?

A. fossils of ice age animals
B. freshwater reptile fossils
C. presence of coal beds
D. layers of sandstone and limestone

Practice Questions

What evidence did Wegener use to suggest that Antarctica had once been closer to the equator?

A. fossils of ice age animals
B. freshwater reptile fossils
C. **presence of coal beds**
D. layers of sandstone and limestone

Practice Questions

The tremendous amount of heat within Earth powers _____.

A. plate tectonics
B. ocean currents
C. weather patterns
D. all of the above

Practice Questions

The tremendous amount of heat within Earth powers _____.

A. **plate tectonics**
B. ocean currents
C. weather patterns
D. all of the above

Extra Credit Option:

- Assessment questions #1-31 on pages 493-494 of the Earth Science textbook.