

Plate Tectonics



Mid-Atlantic Ridge, outside Reykjavic, Iceland

Reading Assignment

- Chapter 7 – Plate Tectonics: A Scientific Revolution Unfolds
- Write down the answers to the Concept Check questions.

Learning Objectives

- <https://macearthscience.weebly.com/41-plate-tectonics.html>
- PLUS: A good 4-minute summary of Plate Tectonics

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- Click link, read, watch video

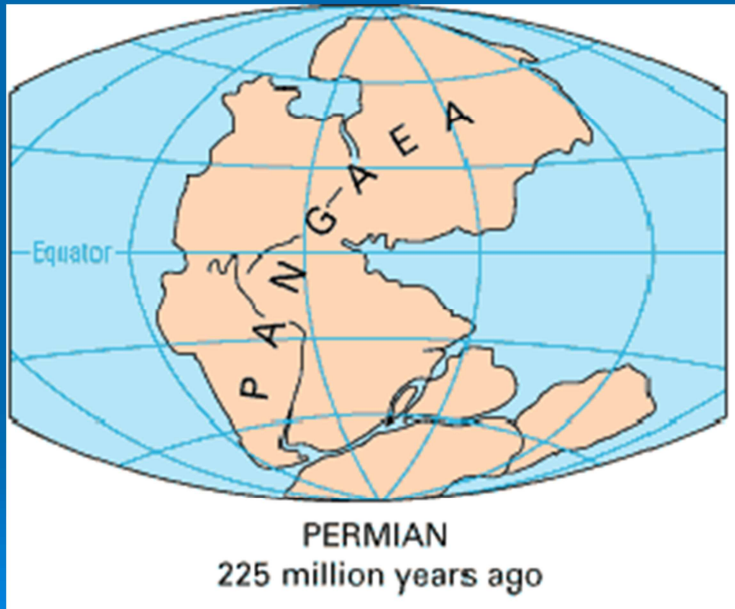
Alfred Wegener

- German meteorologist
- Proponent of the Continental Drift theory/hypothesis



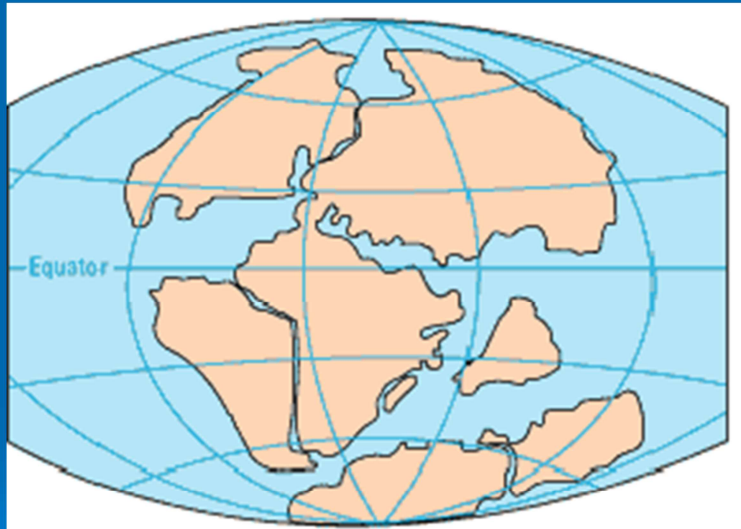
The Hypothesis of Continental Drift

- Supercontinent called Pangaea began breaking apart about 200 million years ago
- Continents “drifted” to present positions
 - Driven by gravitational forces from Moon and Sun.
- Continents “broke” through the ocean crust like an ice breaker.

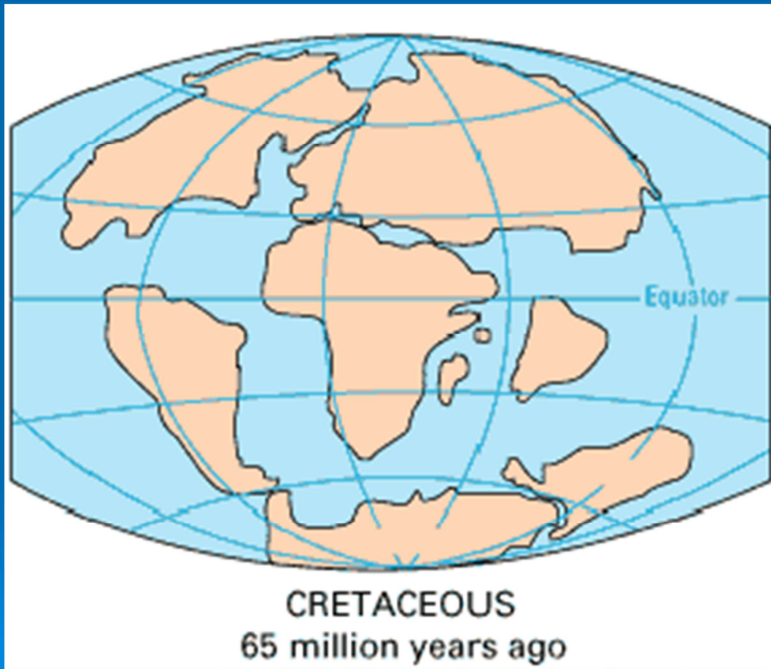


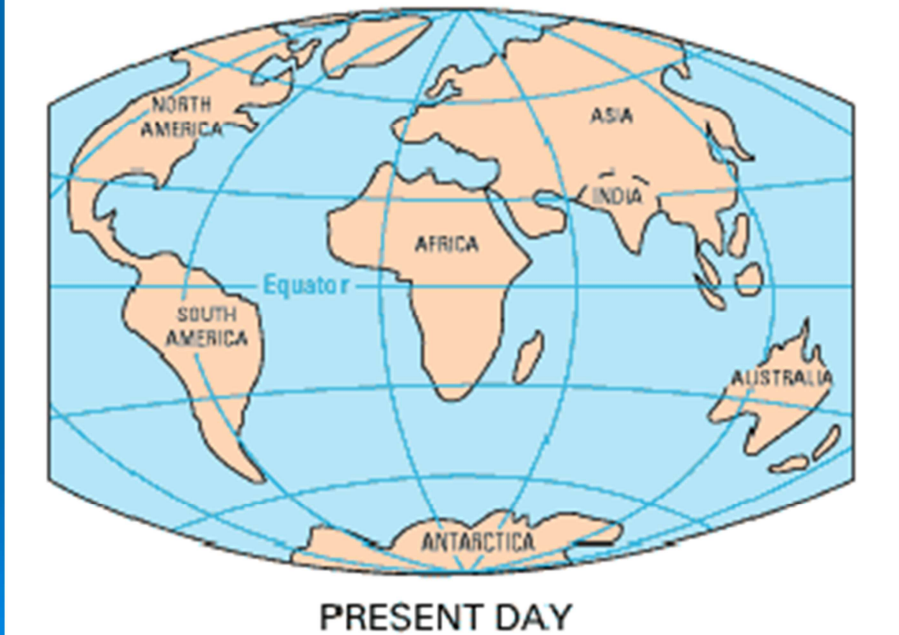


TRIASSIC
200 million years ago



JURASSIC
135 million years ago





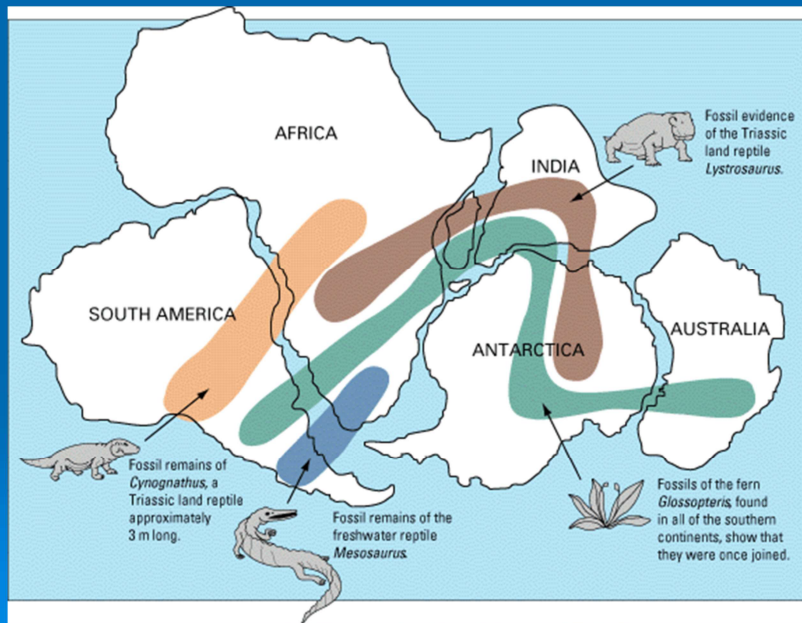
Future positions of the continents

- <https://macearthscience.weebly.com/41-plate-tectonics.html>

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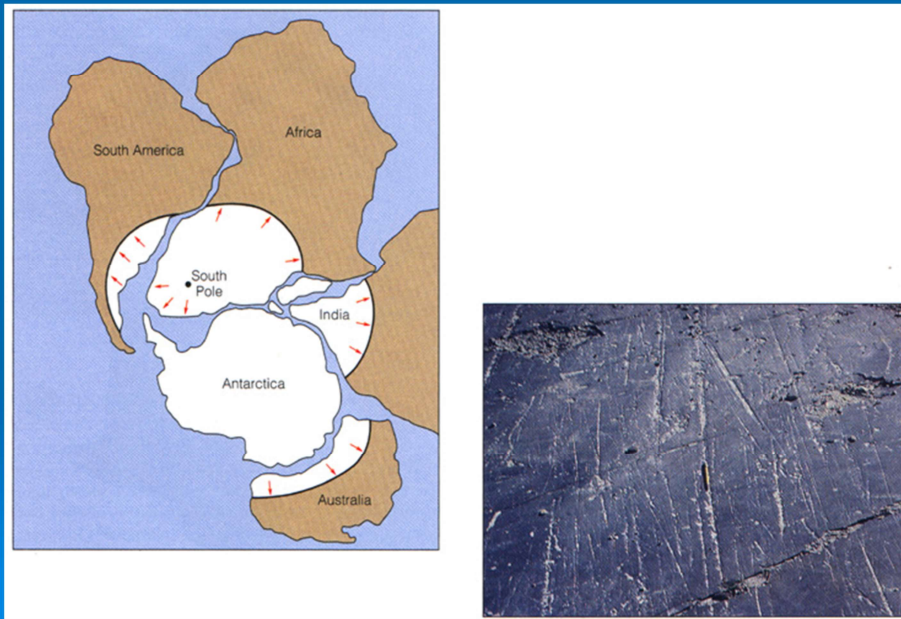
- Click link, watch video.

Wegener's evidence for Continental Drift



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Wegener's evidence for Continental Drift



Wegener's evidence for Continental Drift



Wegener's evidence for Continental Drift



Wegener's evidence for Continental Drift



Scientific community ridicule Wegener's ideas

His theory is rejected

- Continents & Oceans didn't move!
- Not enough evidence
- Most evidence in the southern hemisphere only
- Does not make sense in terms of physics, what forces could move whole continents over large distances?
- **THIS WAS THE MAIN OBJECTION!**

1930

Wegener leaves for Greenland to find evidence for his hypothesis.

He is never seen again

The last photo him

His theory is hotly debated for the next 30 years



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Check Questions

- Explain why the discovery of the fossil remains of Mesosaurus in both South America and Africa, but nowhere else, supports the continental drift hypothesis.
- Early in the twentieth century, what was the prevailing view of how land animals migrated across vast expanses of open ocean?

Plate tectonics: the new paradigm

- More encompassing than continental drift
- Associated with Earth's rigid outer shell
 - Called the lithosphere
 - Consists of several plates
 - Plates are moving slowly
 - Largest plate is the Pacific plate
 - Plates are mostly beneath the ocean

Plate tectonics: the new paradigm

- Asthenosphere
 - Exists beneath the lithosphere
 - Hotter and weaker than lithosphere
 - Allows for motion of lithosphere
- Plate boundaries
 - All major interactions among plates occur along their boundaries

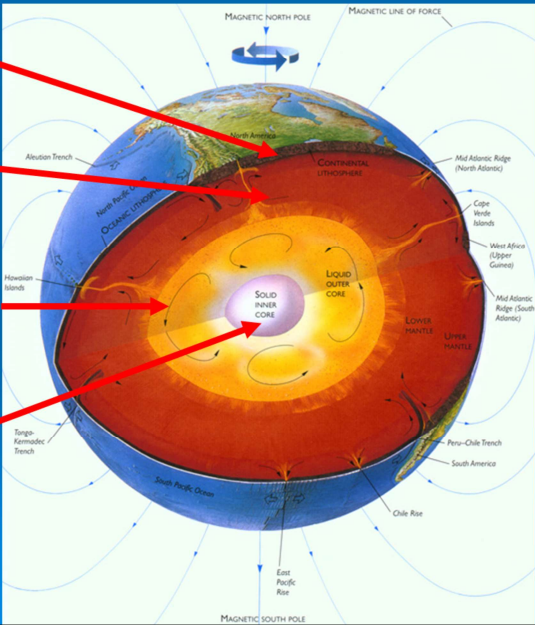
Earth Structure

Lithosphere

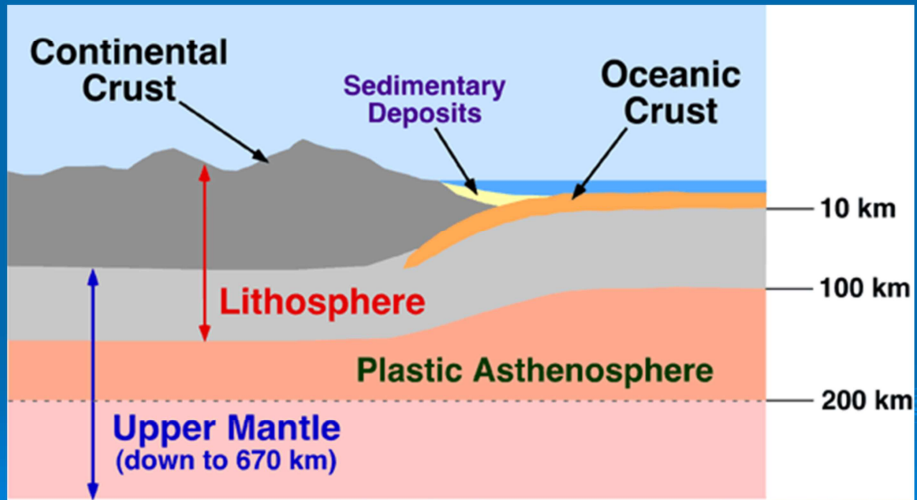
Mantle

Outer Core
(Liquid)

Inner Core
(Solid)



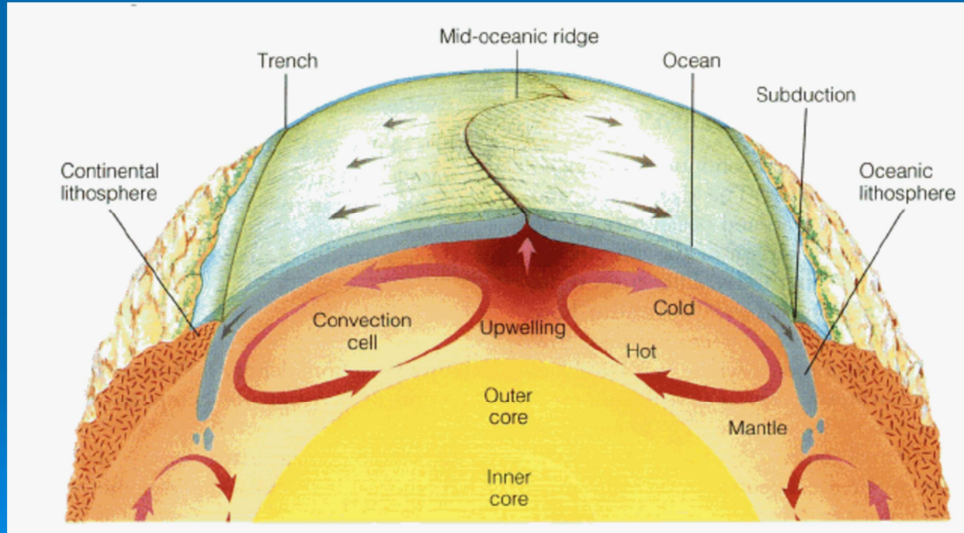
Lithosphere



Asthenosphere

- Exists beneath the lithosphere.
- Hotter and weaker than lithosphere (plastic)
- Allows for lithosphere to “float” or “slide” on top of it.

Mantle Convection



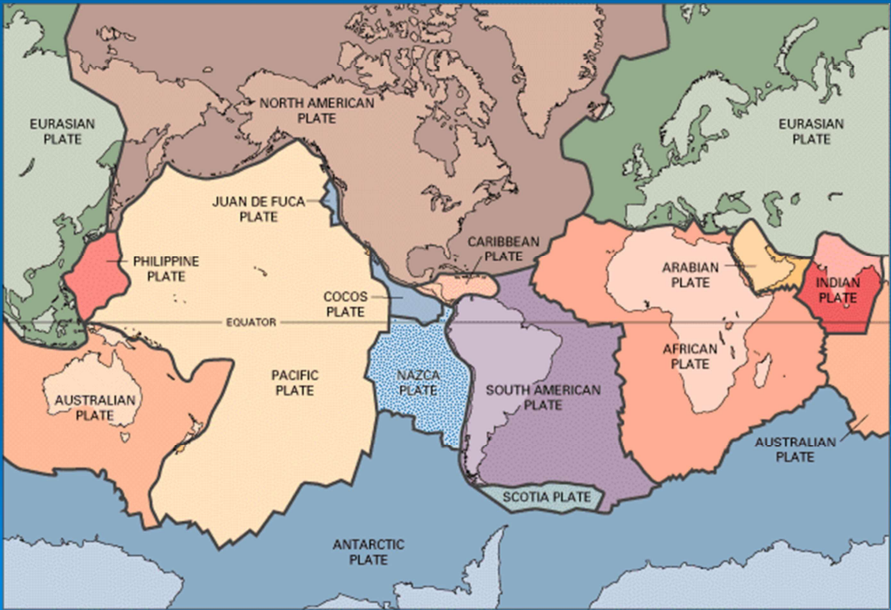
Mantle Convection

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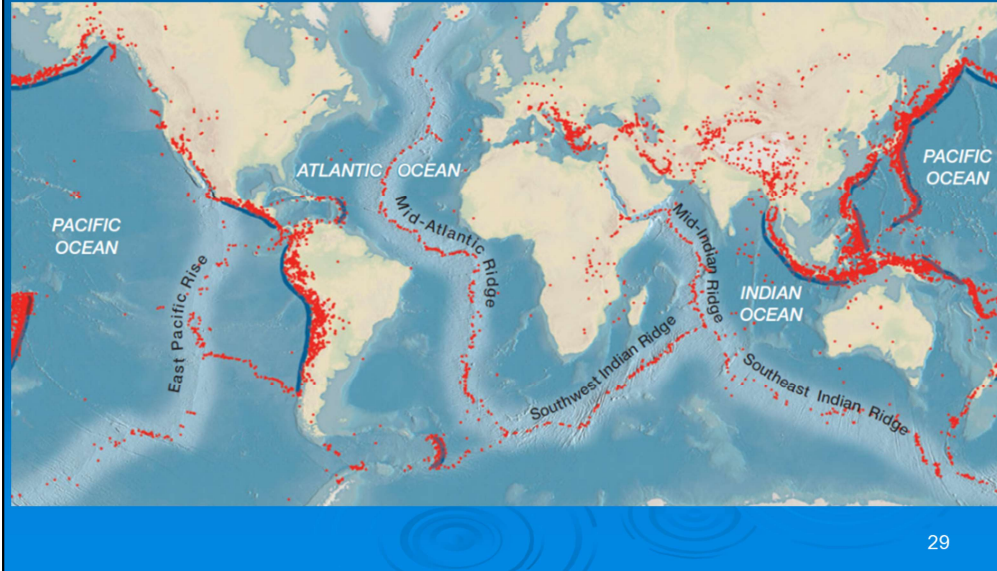
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- Click link, watch video.

The Plates



Map of Earthquake Epicenters



Check Questions

- Compare and contrast the lithosphere and the asthenosphere.
- Name five of the major tectonic plates.

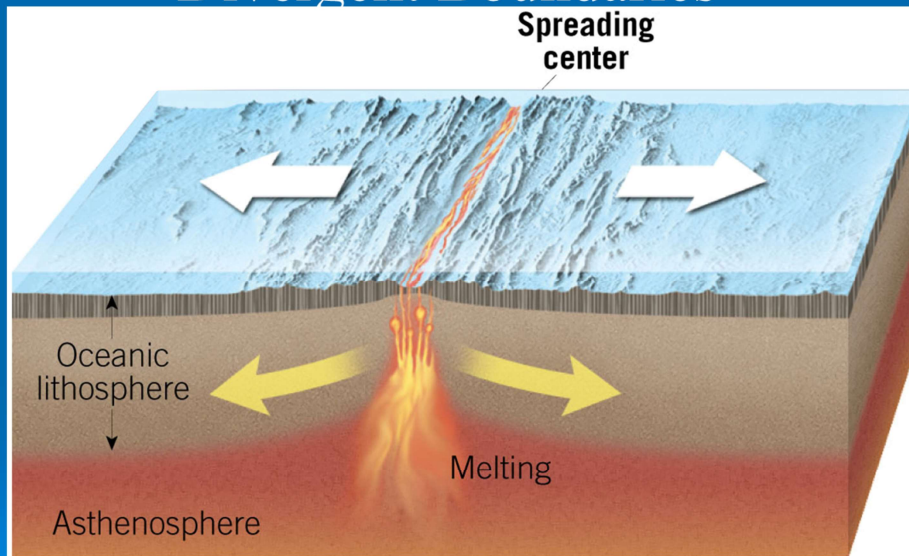
Plate Boundaries

- Associated with plate boundaries:
 - Seismic Activity
 - Volcanism
 - Mountain Building
- Types of Plate Boundaries
 - Divergent
 - Convergent
 - Transform

Divergent Boundaries

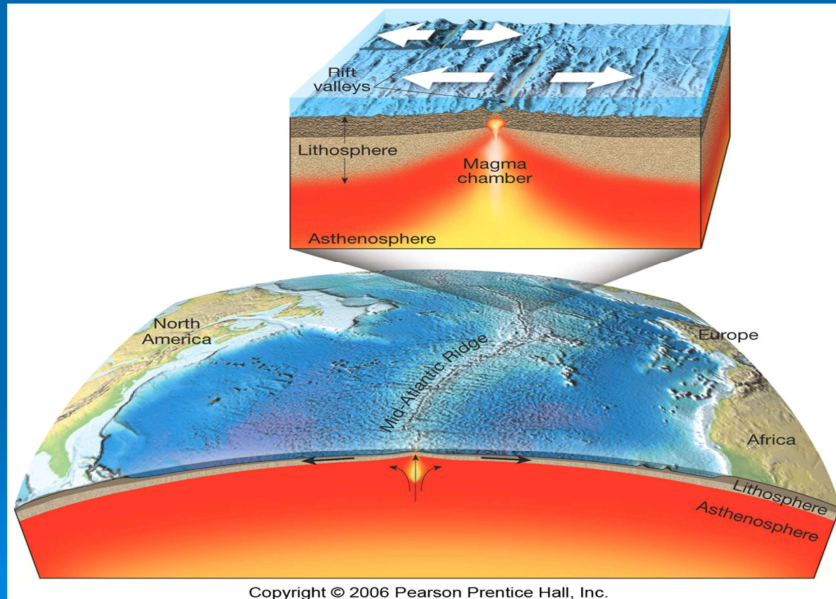
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Divergent Boundaries



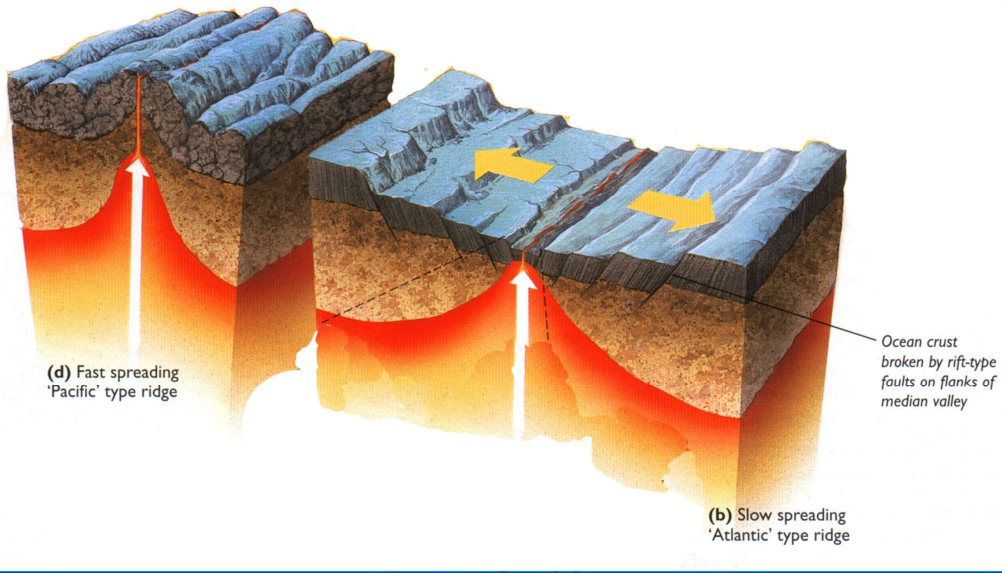
A. Divergent plate boundary ———

Divergent Boundaries

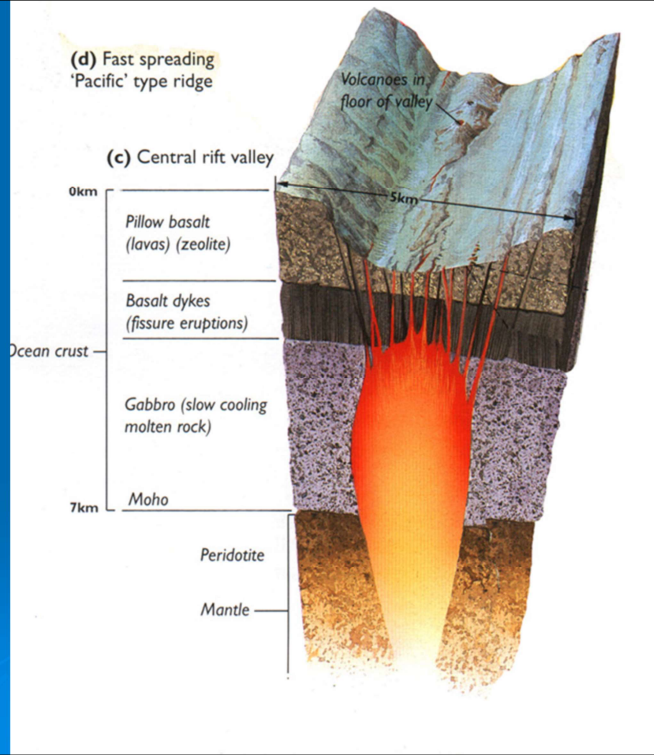


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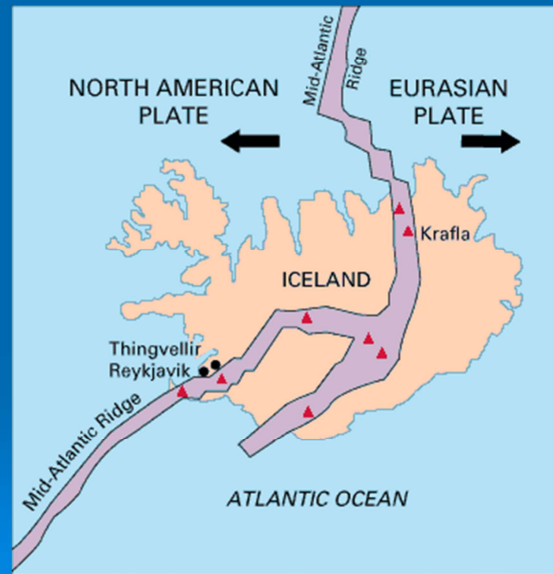
new basaltic magma rises to the surface along the ridge
forming new oceanic crust



What the central rift looks like in a spreading ridge



Continental Rift zone E.g. Africa and Iceland





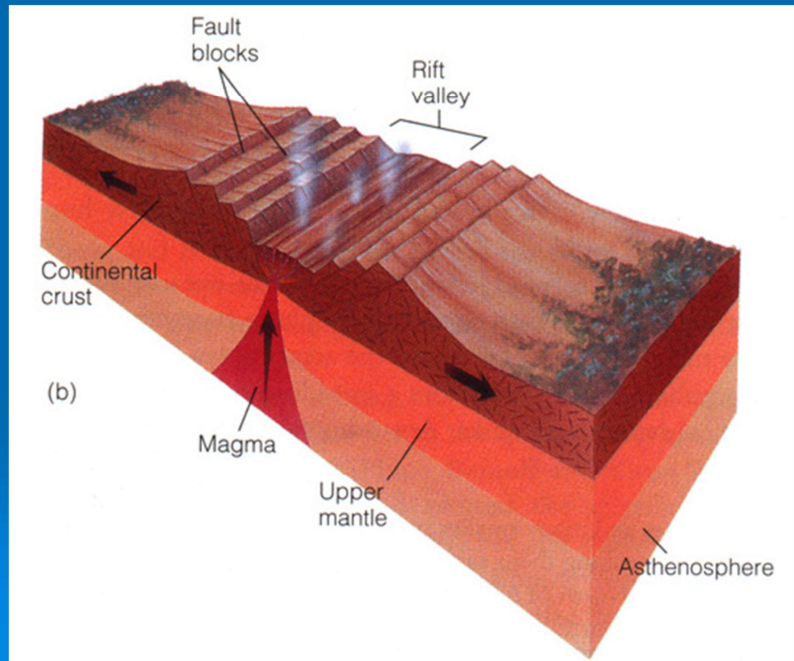
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Divergent plate boundaries on land form **rift valleys**.

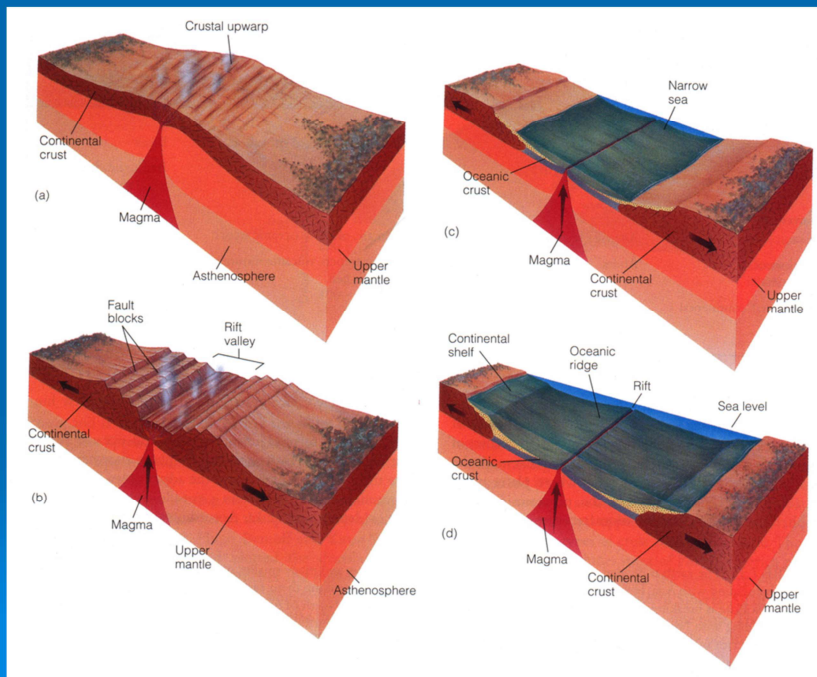
These rift valleys often have volcanoes lining them.



Diagram of a rift valley E.g. East African rift



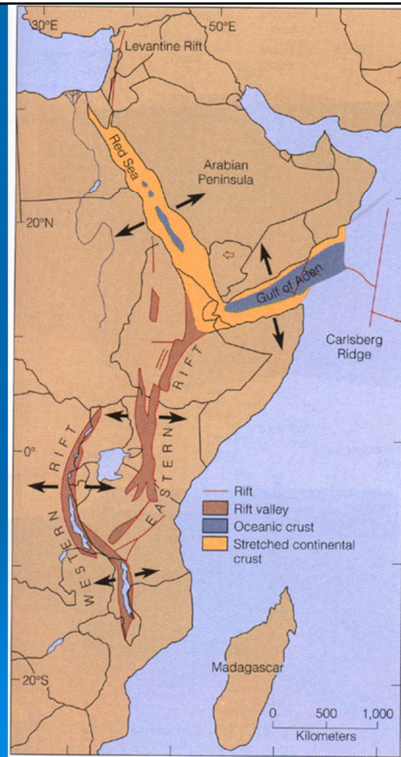
Rift valleys will increase in size till water fills them to form a **Sea**



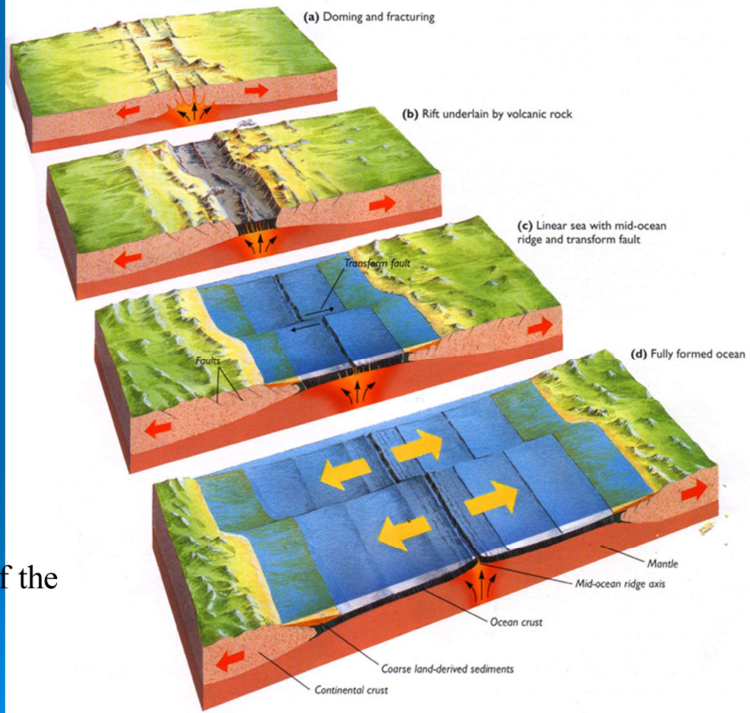
The **Red Sea** and the **Gulf of Aden** were once rift valleys.

So was the Atlantic Ocean!

A Rift Valley may be forming in Nevada as we speak...



The formation of the Atlantic ocean



Video

- Flyover of a continental rift zone.
 - <https://macearthscience.weebly.com/41-plate-tectonics.html>

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- Click link, watch video.

Check Questions

- Name some of the areas where Continental Rifting is happening today?
- What is the average rate of seafloor spreading in modern oceans?

Convergent Boundaries

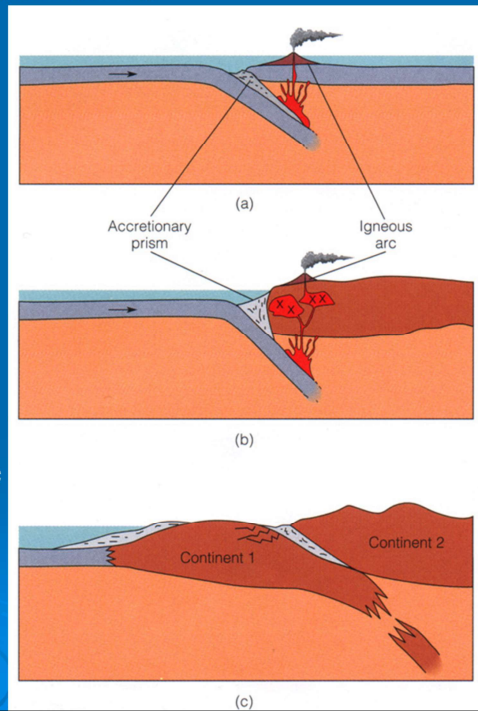
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•Types of Convergent plate boundaries

Oceanic-oceanic convergence
E.g. **Japan, New Zealand**

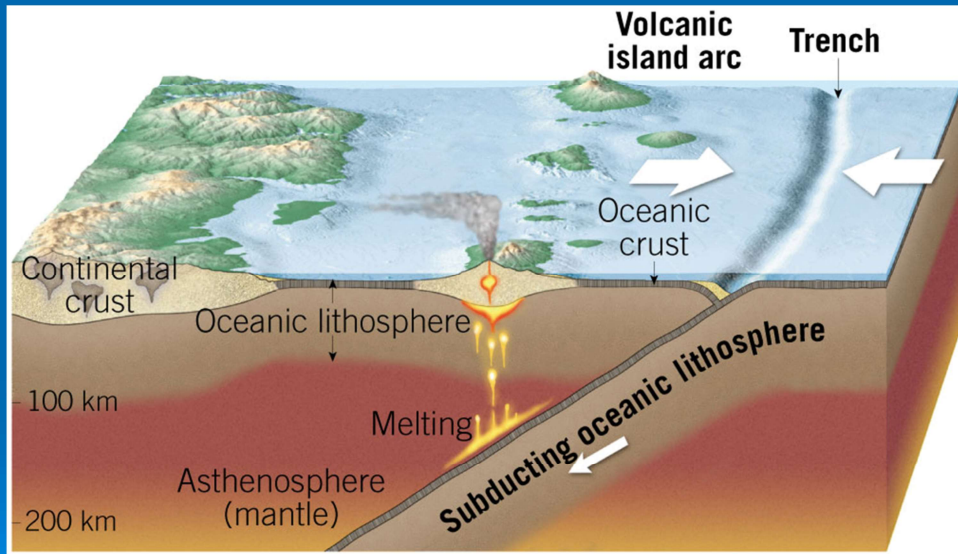
Oceanic - continental convergence
E.g. **Andes, Cascades**

Continental-continental convergence
E.g. **Himalayas**



- Oceanic – Oceanic convergence creates volcanic island arcs.
- Oceanic – Continental convergence creates continental volcanic arcs.
- Continental – Continental convergence creates mountains but not volcanoes.

Oceanic - Oceanic Convergence

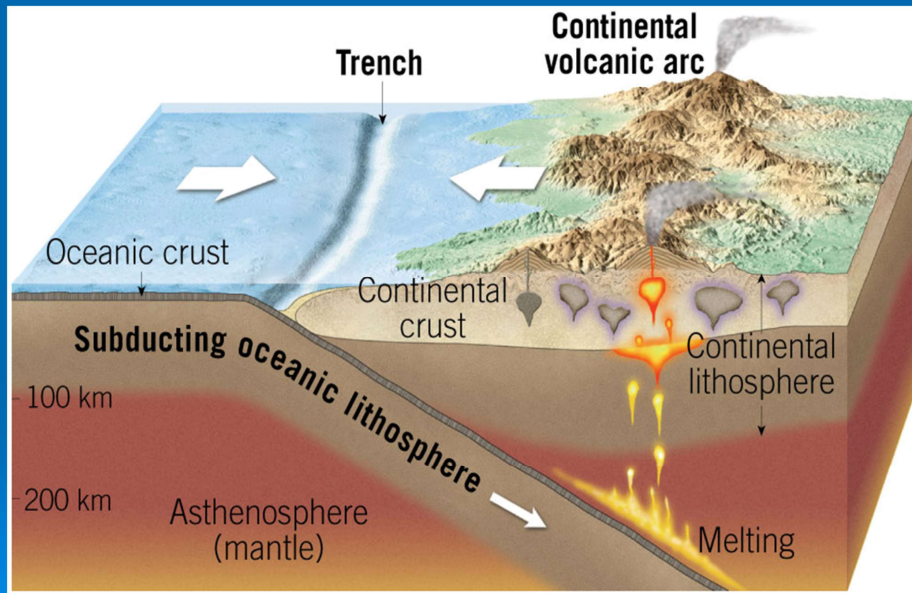




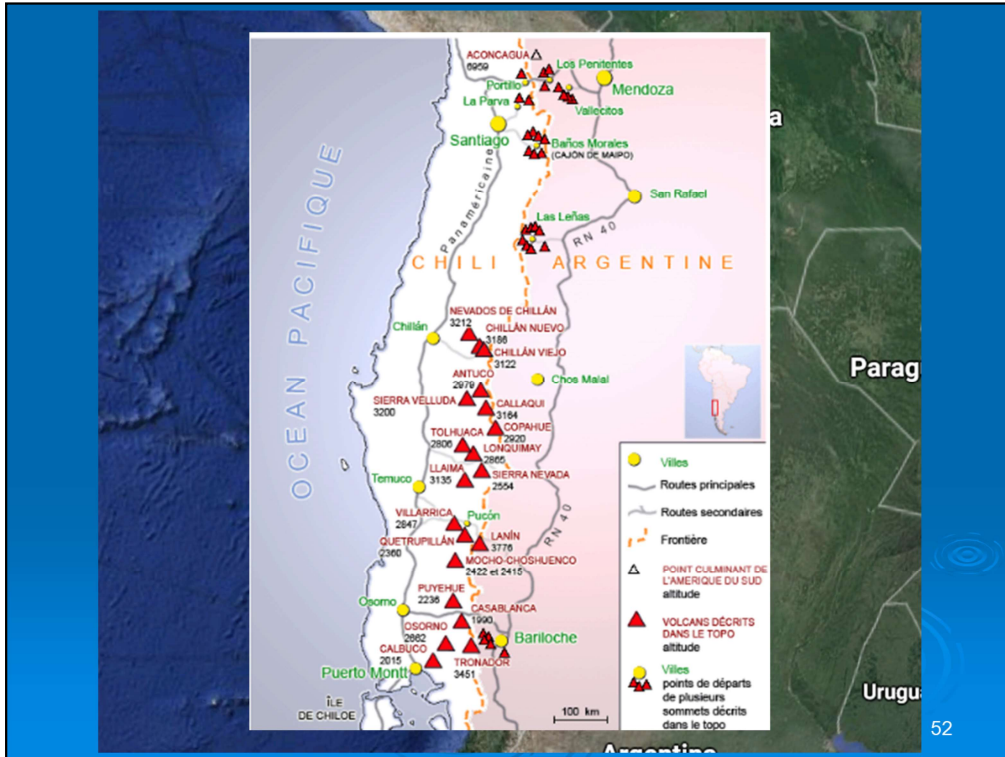
Mount Fuji



Oceanic - Continental convergence



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Aconcagua (Andes)



Mt. Rainier

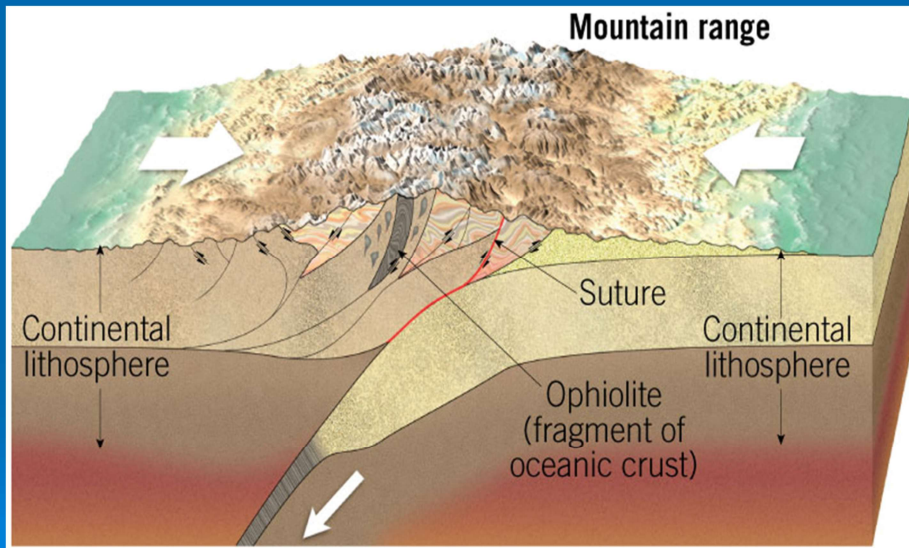


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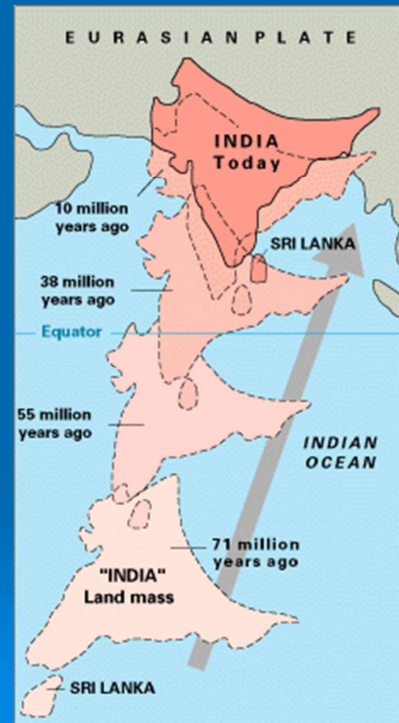
Mt. St. Helens

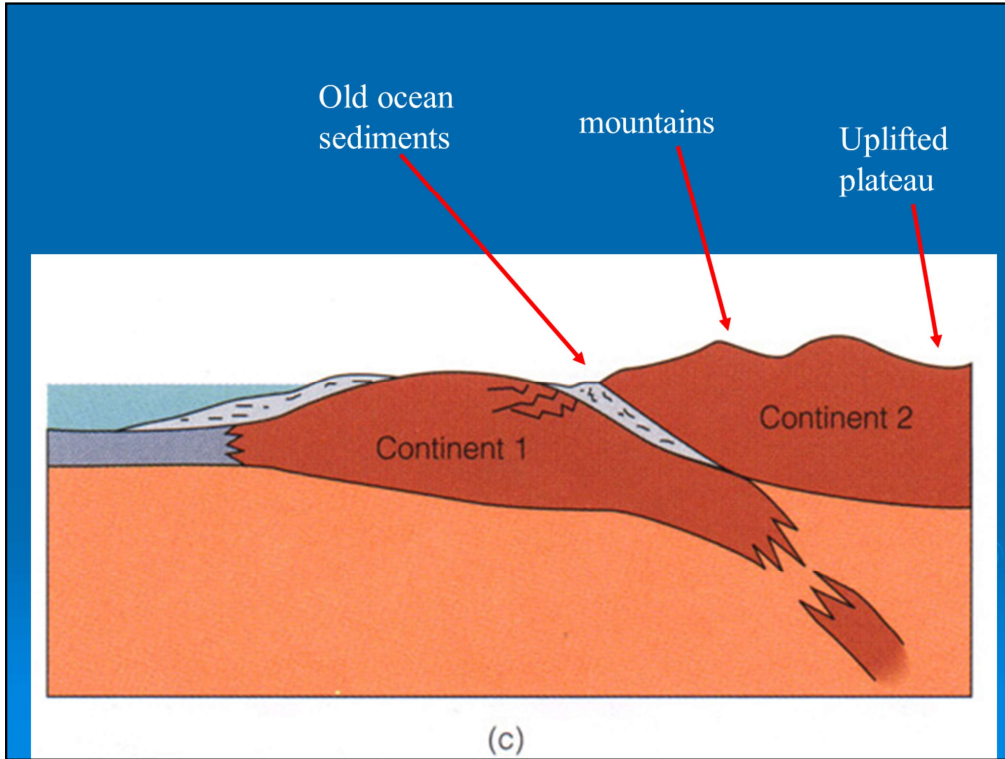


Continental - Continental convergence



The sub-continent of India has collided with the Eurasian continent to form the Himalayas





Himalayas



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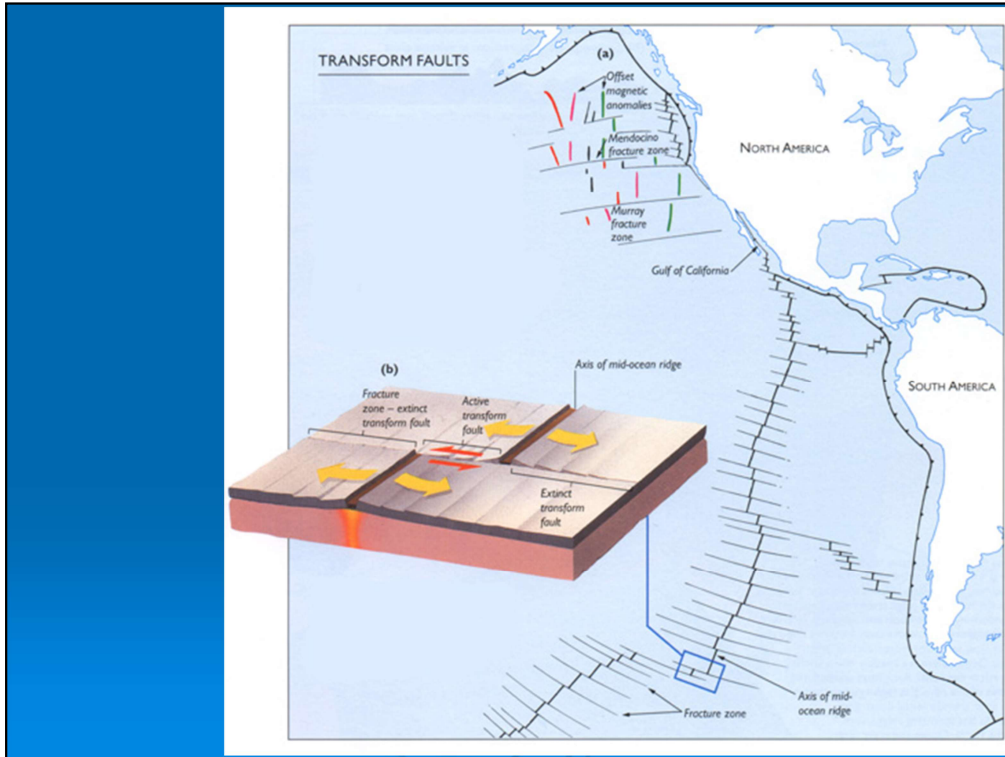
Check Questions

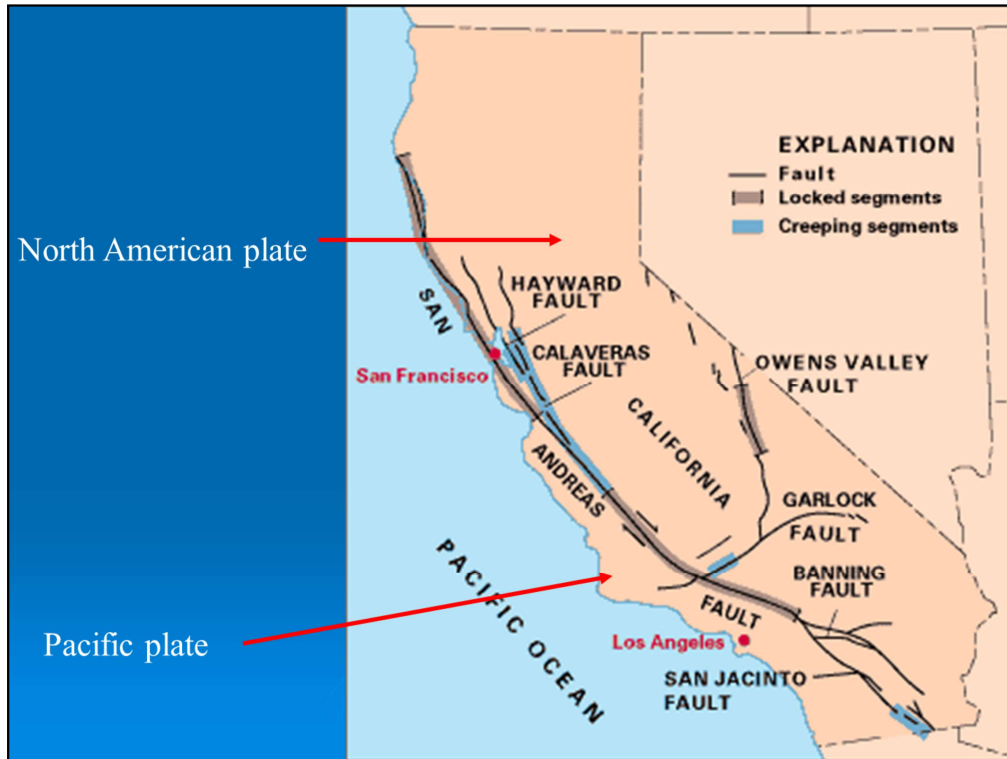
- Compare a continental volcanic arc and a volcanic island arc.
 - Type of plate boundary.
 - Characteristics of the volcanos.
- Why does oceanic lithosphere subduct, while continental lithosphere does not?

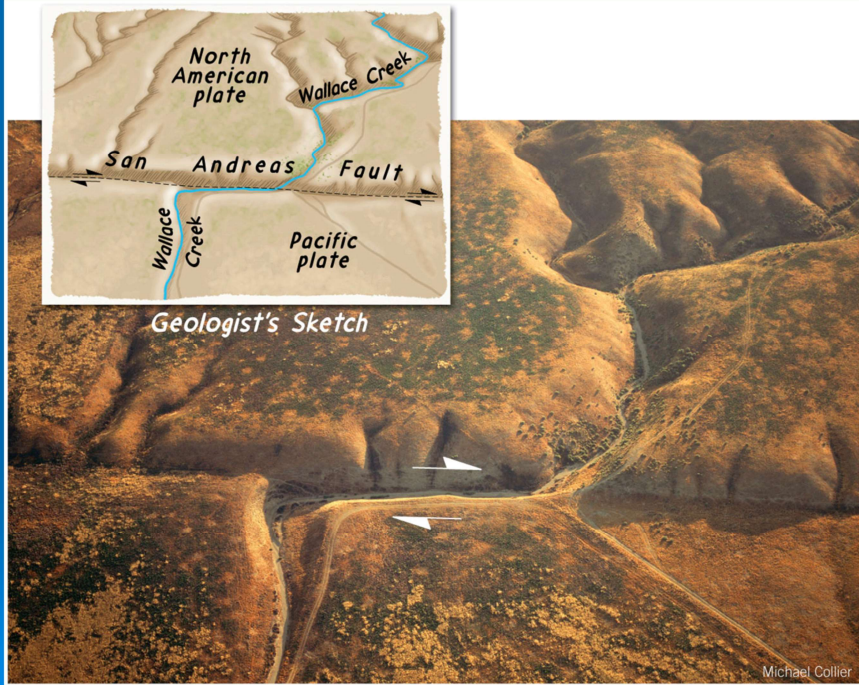
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A continental volcanic arc occurs on the edge of a continental land mass near an ocean-continent convergent plate boundary. These volcanoes tend to produce more granitic to intermediate magma. Granitic magma usually erupts violently. A volcanic island arc occurs at ocean-ocean plate convergent plate boundaries and produces an island chain in the ocean; these volcanic islands are basaltic. Basaltic magma erupts quiescently.

Transform Boundaries







Michael Collier

Volcanoes and Plate boundaries

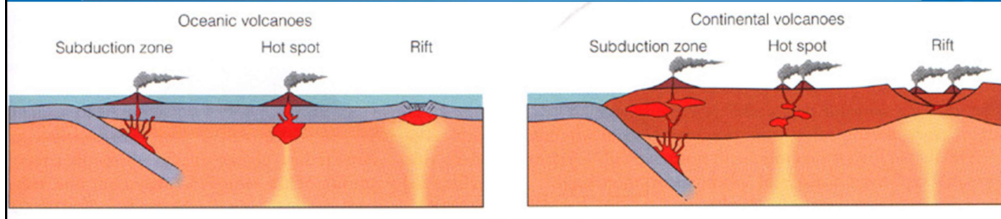
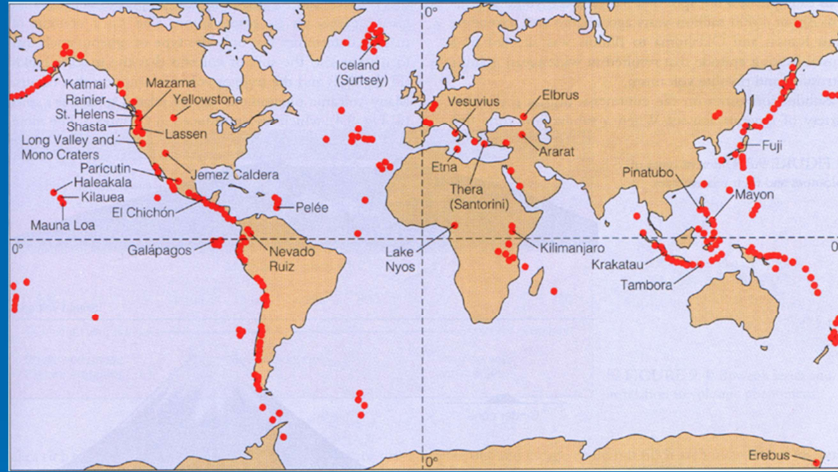









Plate boundaries and Hot spots

EXPLANATION

-  Divergent plate boundaries—
Where new crust is generated as the plates pull away from each other.
-  Convergent plate boundaries—
Where crust is consumed in the Earth's interior as one plate dives under another.
-  Transform plate boundaries—
Where crust is neither produced nor destroyed as plates slide horizontally past each other.
-  Plate boundary zones—Broad belts in which deformation is diffuse and boundaries are not well defined.
-  Selected prominent hotspots

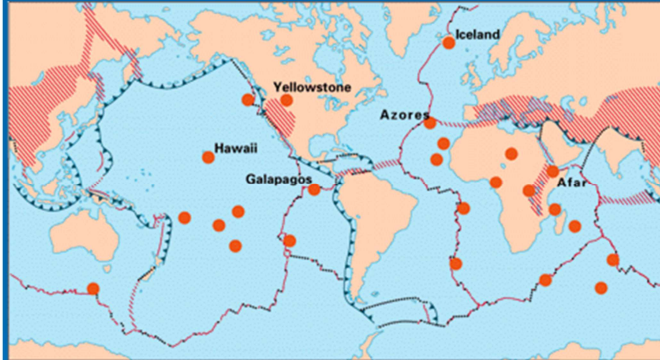


Plate tectonics: the new paradigm

- Types of plate boundaries
 - Transform fault boundaries
 - Plates slide past one another
 - No new crust is created or destroyed
 - Transform faults
 - Most join two segments of a mid-ocean ridge
 - Aid the movement of oceanic crustal material

Testing the plate tectonics model

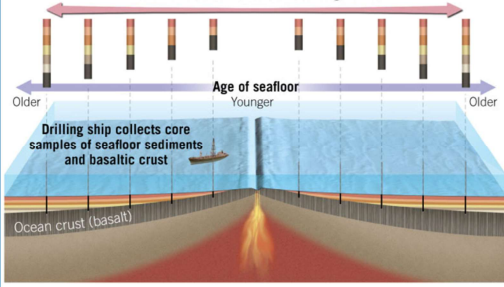
- Evidence from ocean drilling
 - Some of the most convincing evidence confirming seafloor spreading has come from drilling directly into ocean-floor sediment
 - Age of deepest sediments
 - Thickness of ocean-floor sediments verifies seafloor spreading

Testing the plate tectonics model

- ❖ Hot spots and mantle plumes
 - Caused by rising plumes of mantle material
 - Volcanoes can form over them (Hawaiian Island chain, Yellowstone)
 - Mantle plumes
 - Long-lived structures
 - Some originate at great depth, perhaps at the mantle-core boundary

Deep-Sea Drilling

Core samples show that the thickness of sediments increases with distance from the ridge crest.




The diagram illustrates a cross-section of a mid-ocean ridge. At the center is the ridge crest, where magma is shown rising. The seafloor is labeled 'Ocean crust (basalt)'. Above the crust is a layer of sediments. A red double-headed arrow at the top indicates that the thickness of these sediments increases as the distance from the ridge crest increases. A purple double-headed arrow below it indicates the 'Age of seafloor', which is 'Younger' at the ridge crest and 'Older' further away. A drilling ship is shown on the left side of the ridge, with a vertical drill core extending down into the sediments and crust. The text 'Drilling ship collects core samples of seafloor sediments and basaltic crust' is placed near the ship.

Drilling ship collects core samples of seafloor sediments and basaltic crust

Age of seafloor: Older, Younger, Older

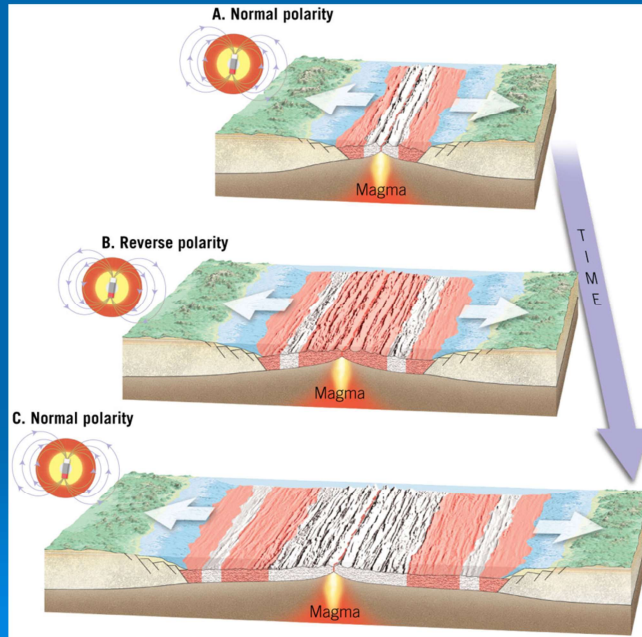
Ocean crust (basalt)

Chikyu is a state-of-the-art drilling ship designed to drill up to 7,000 meters (more than 4 miles) below the seafloor.

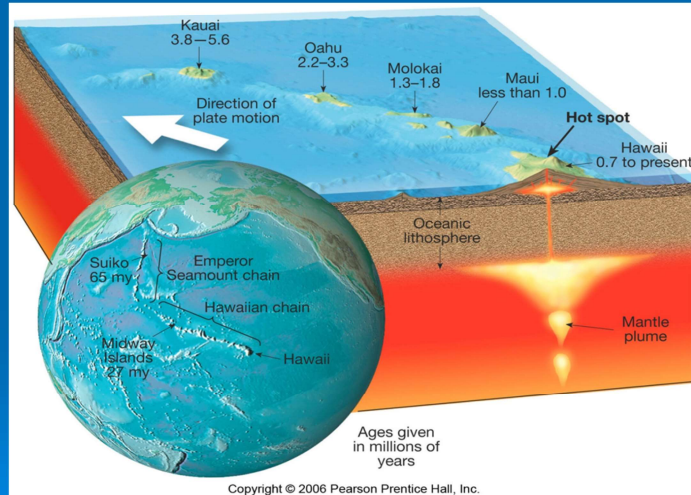


AP Photo/Bruce Inouye

Magnetic Reversals and Seafloor Spreading



The Hawaiian Islands have formed over a stationary hot spot

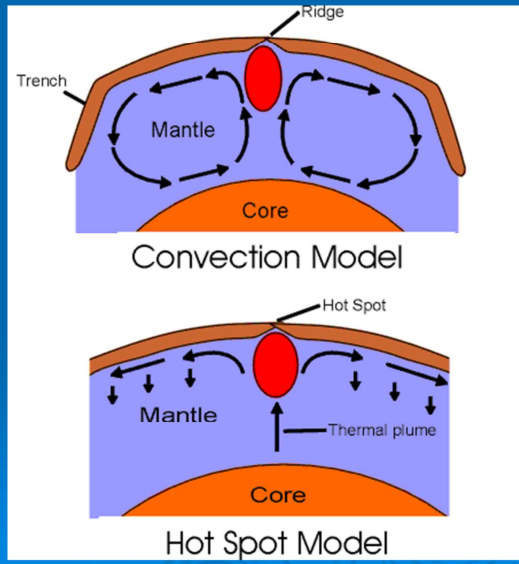


Yellowstone too

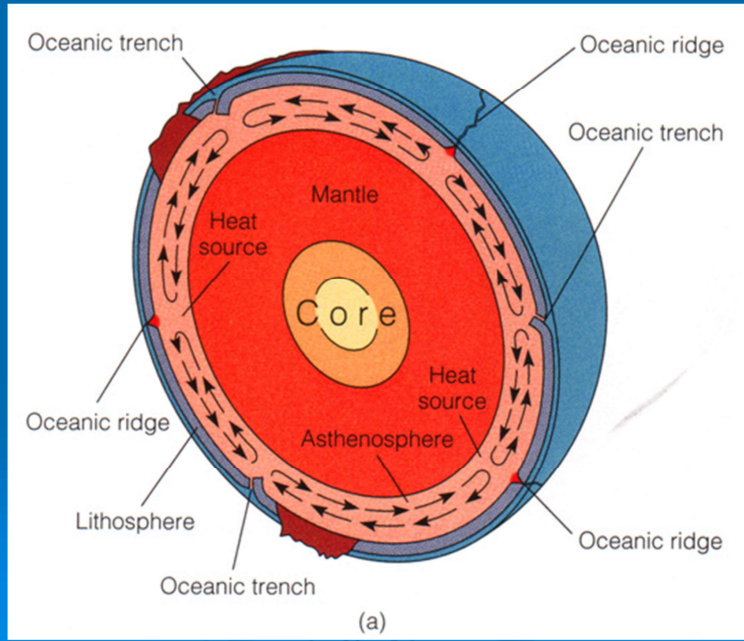


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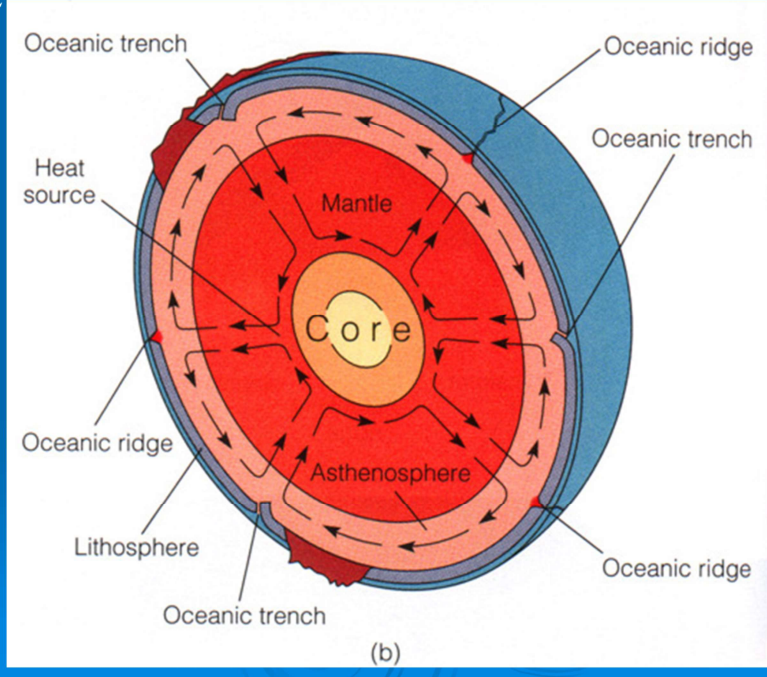
Hot Spots



Model 1



Model 2





Slides removed.