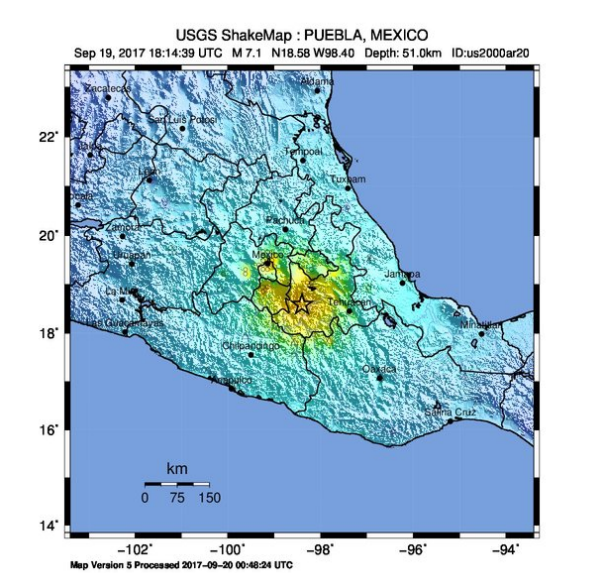
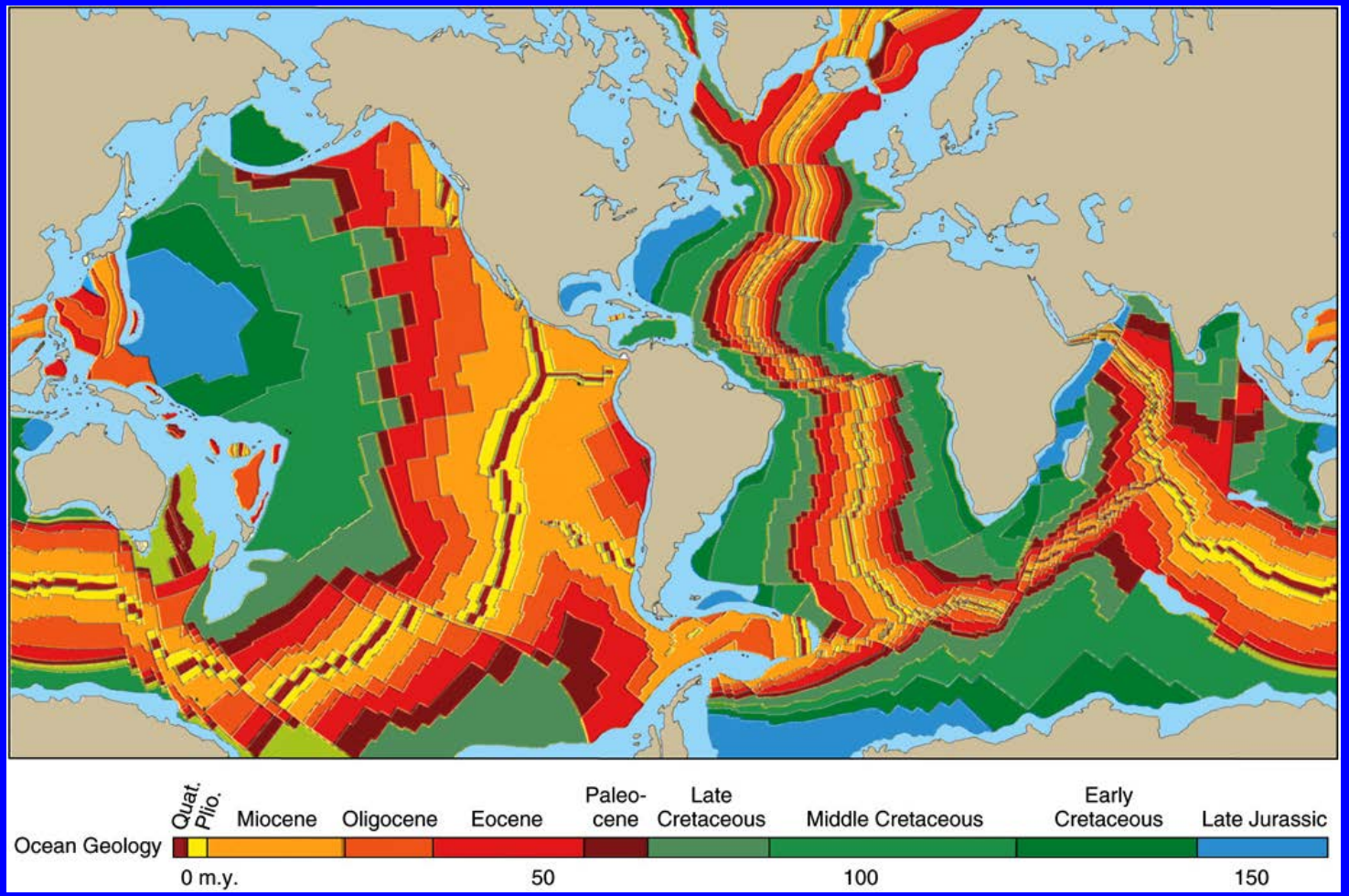
ANOTHER MEXICAN EARTHQUAKE!



Magnitude 7.1, Tuesday Sept. 19, 2017

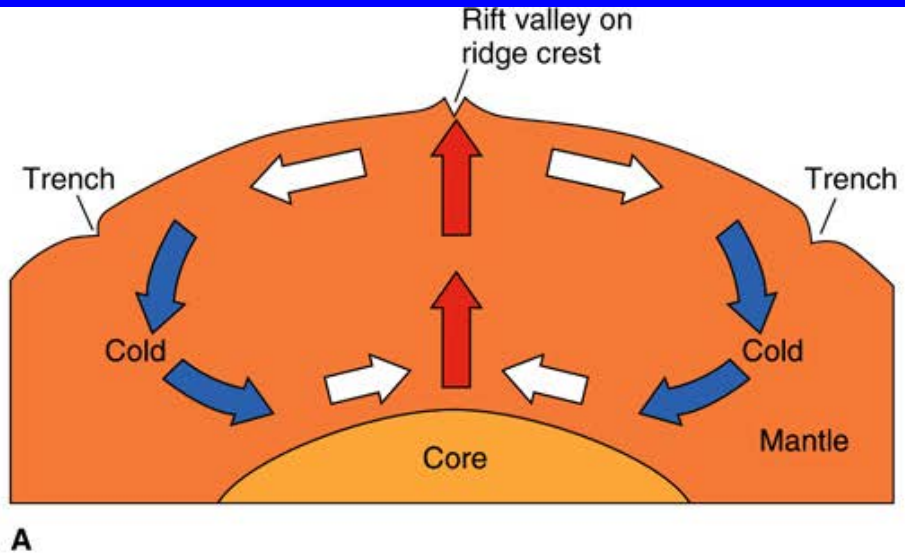
Why is there no oceanic crust older than 200 million years?

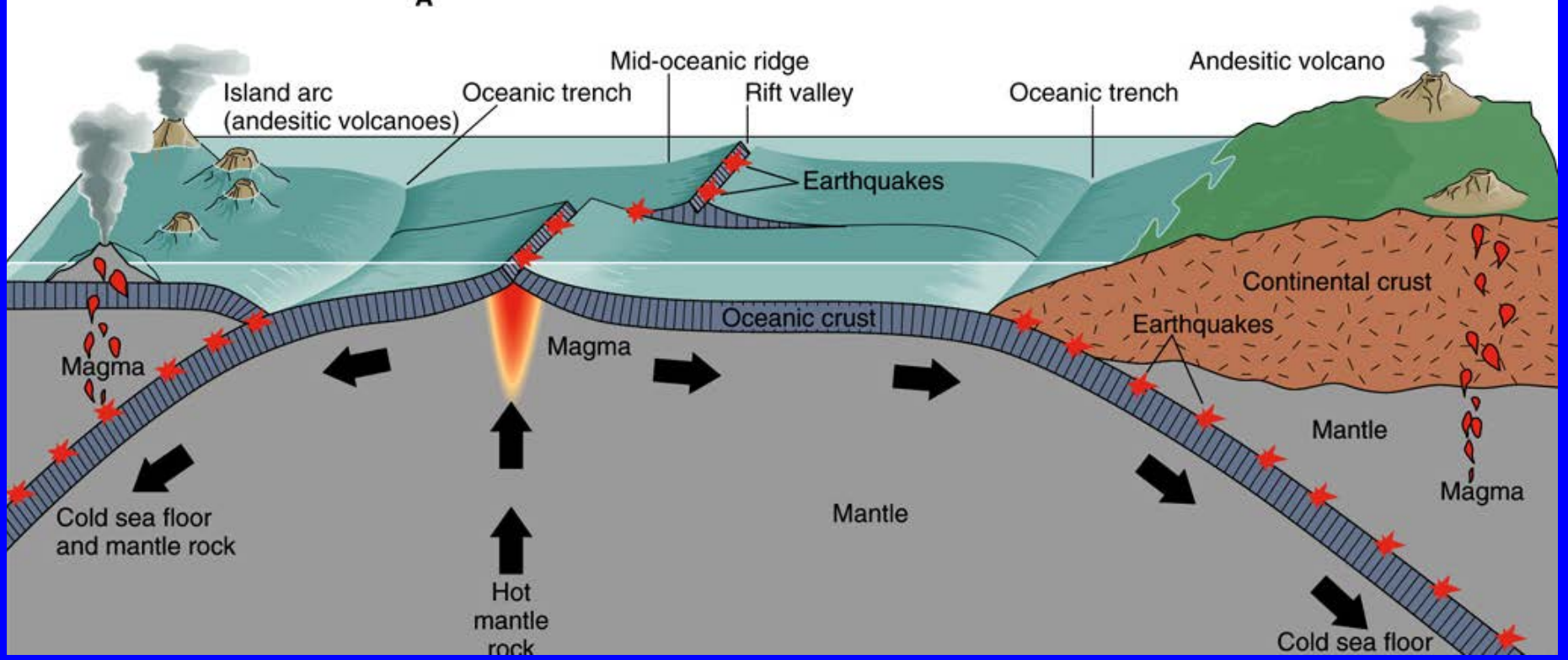


SUBDUCTION

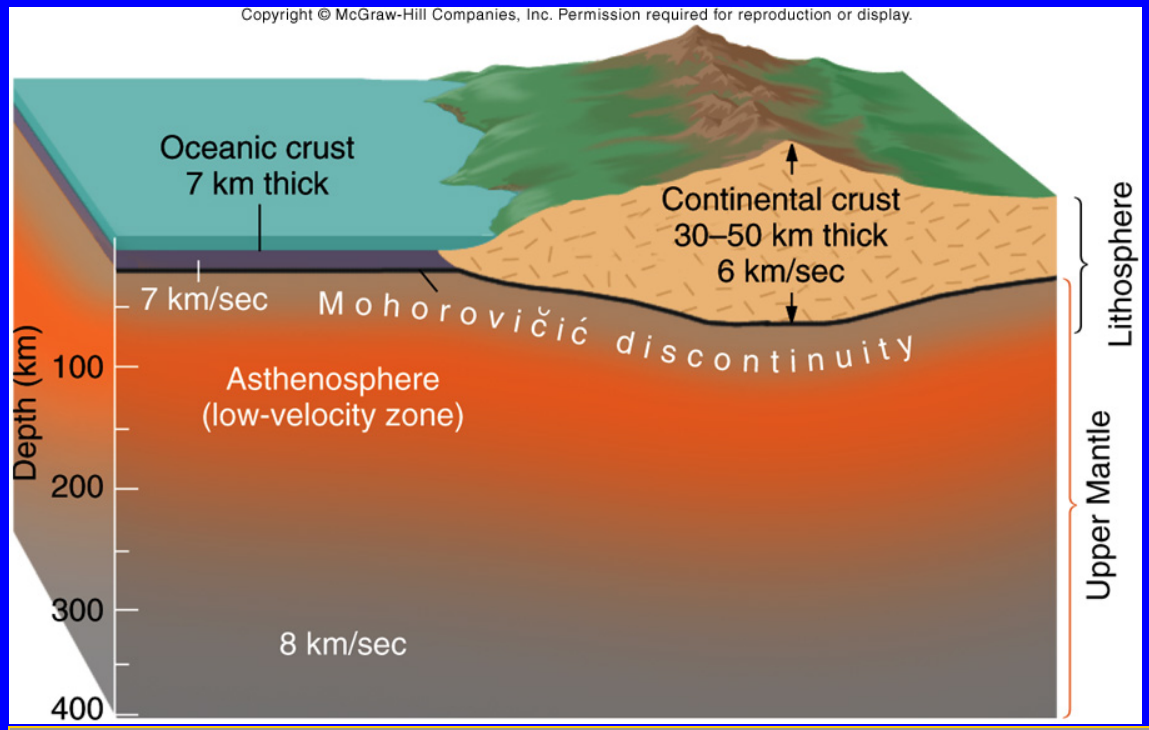
- If new oceanic crust is being continuously created along the earth's spreading ridge system, then we must find some way to re-cycle it back into the mantle. [WHY? –otherwise the earth would be expanding!!!!]
- Old oceanic crust (>200 million years) is returned to the mantle at the deep ocean trenches.
- These are known as **SUBDUCTION ZONES**
- Most subduction zones are found in the Pacific Ocean. This means that the Pacific Ocean is shrinking and the Atlantic Ocean is expanding.

Convection in the mantle





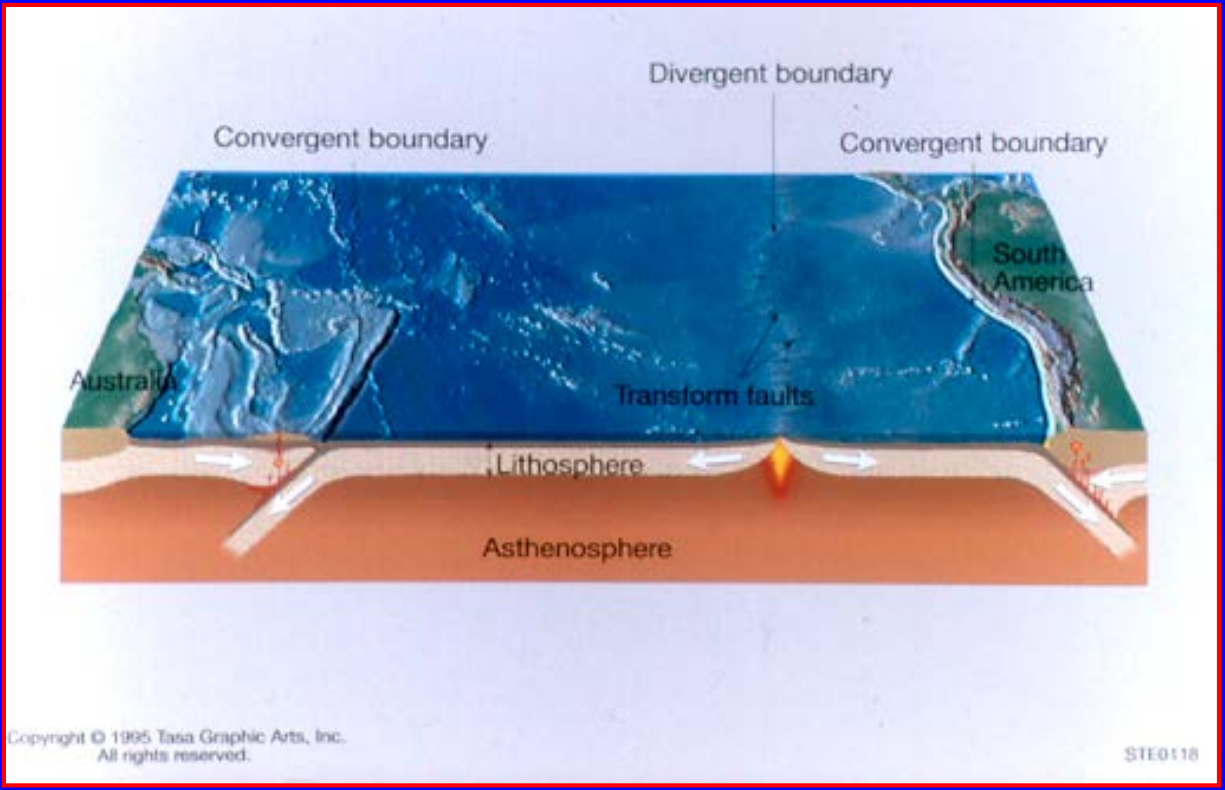
Lithosphere Recap



Lithosphere (or plate) – is rigid and is composed of crust and upper mantle. Thickness varies from 10-150 km.

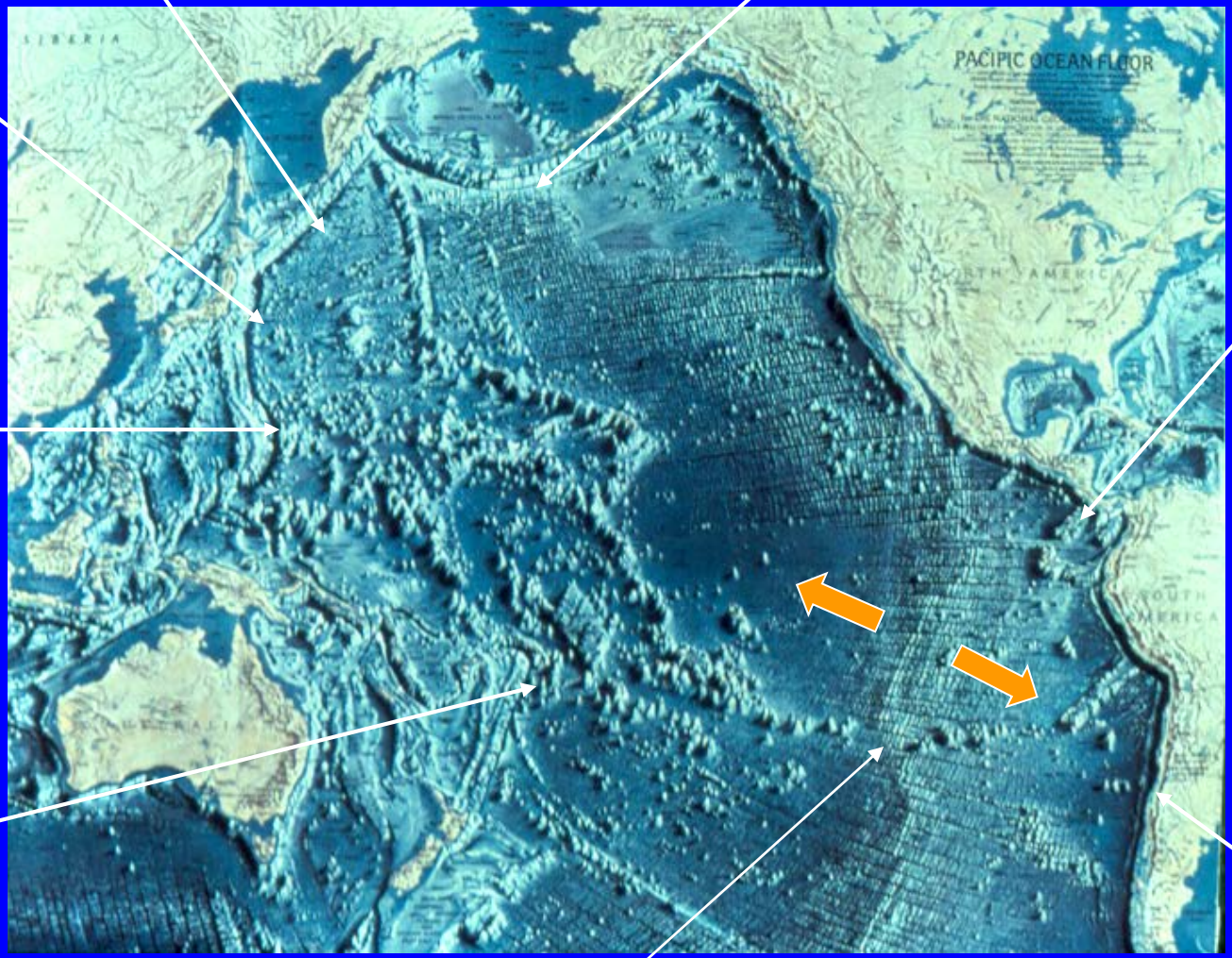
Asthenosphere – is soft, plastic and convecting. Melting of the asthenosphere produces volcanic rocks at ocean ridges.

SUBDUCTION



- Cross-section through the southern Pacific Ocean
- New oceanic crust and lithosphere are created at the East Pacific Rise
- Old oceanic crust and lithosphere are subducted at deep ocean trenches (Tonga trench and Chile trench).

Pacific Ocean



Kamchatka trench

Aleutian trench

Japan trench

Costa Rica trench

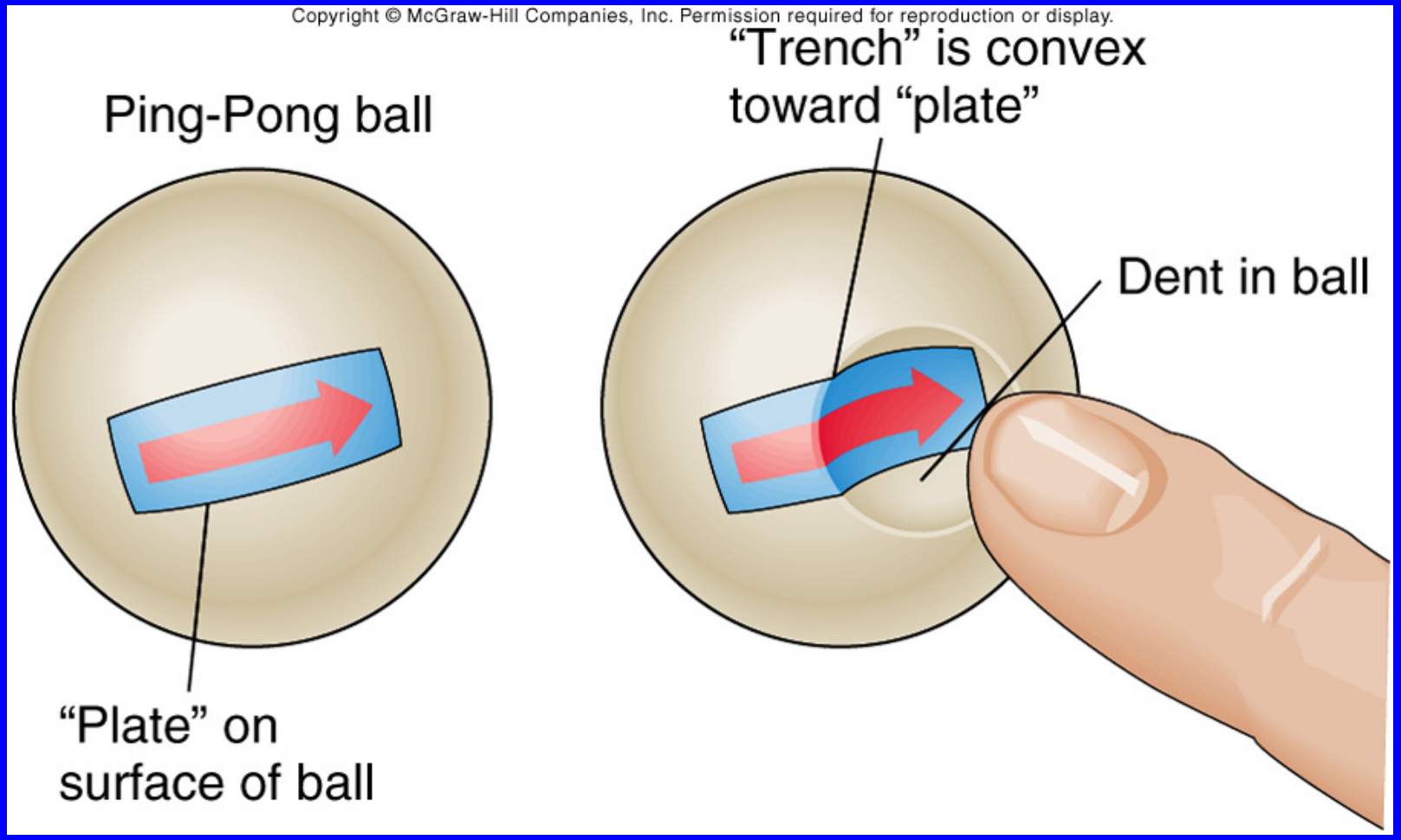
Marianas trench

Tonga trench

East Pacific Rise

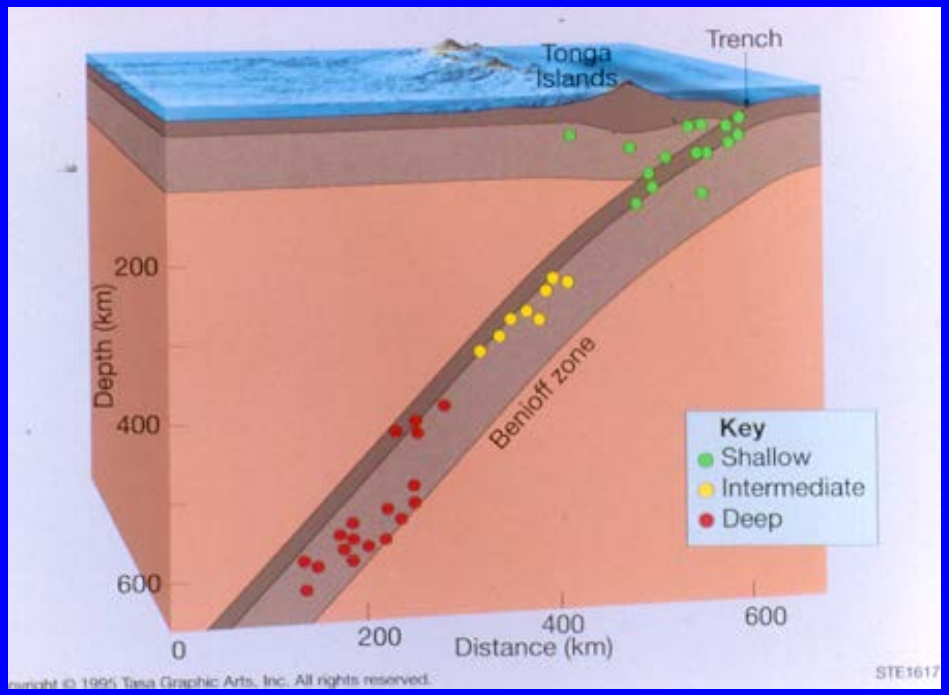
Chile trench

Notice that the trenches are often curved with the convex side facing the direction of subduction. This is because the earth is spherical



Consequently by observing the curvature of the trench we can easily determine which side is being subducted

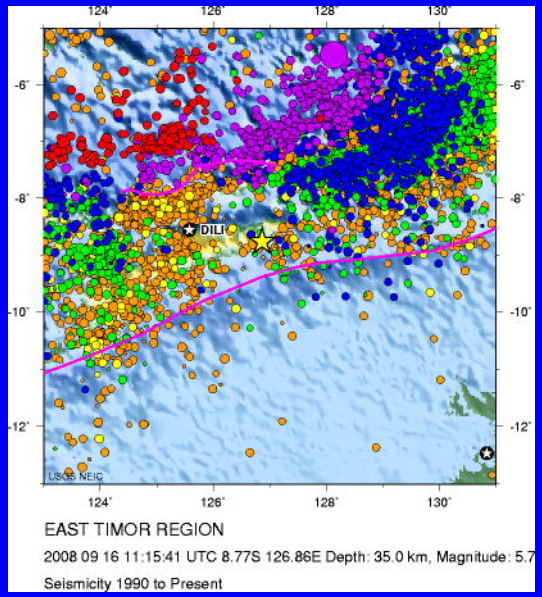
Details of a subduction zone



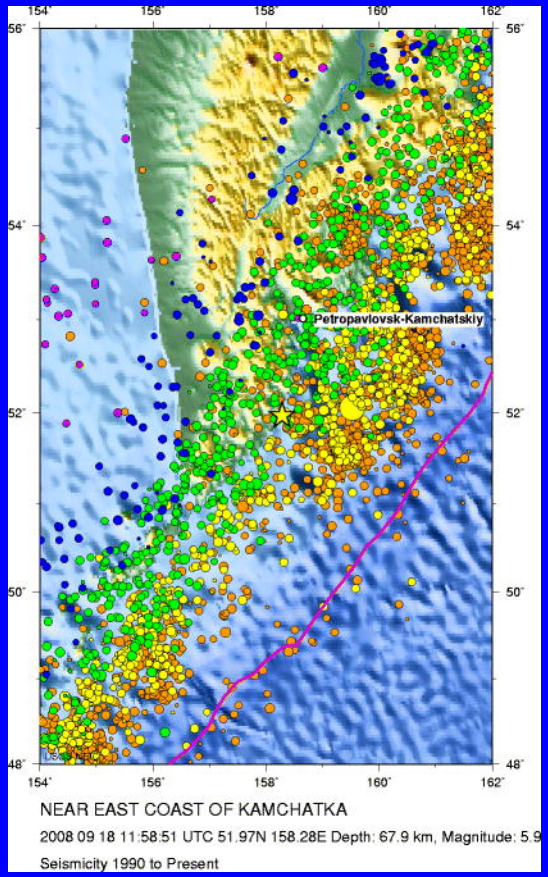
Example from Tonga
In the western Pacific.

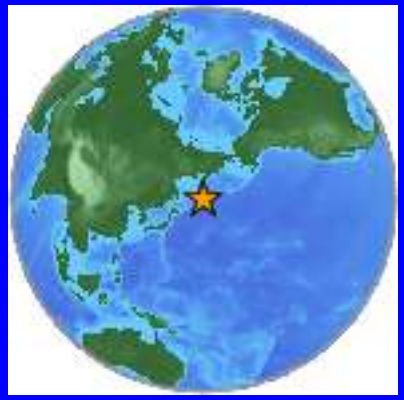
- Slab of lithosphere descends back into the mantle at a deep ocean trench.
- Earthquakes trace the descent of the slab into the mantle (**Benioff Zone**).
- Earthquakes can be detected to a depth of 600 km (what happens below this?).

What is the evidence?



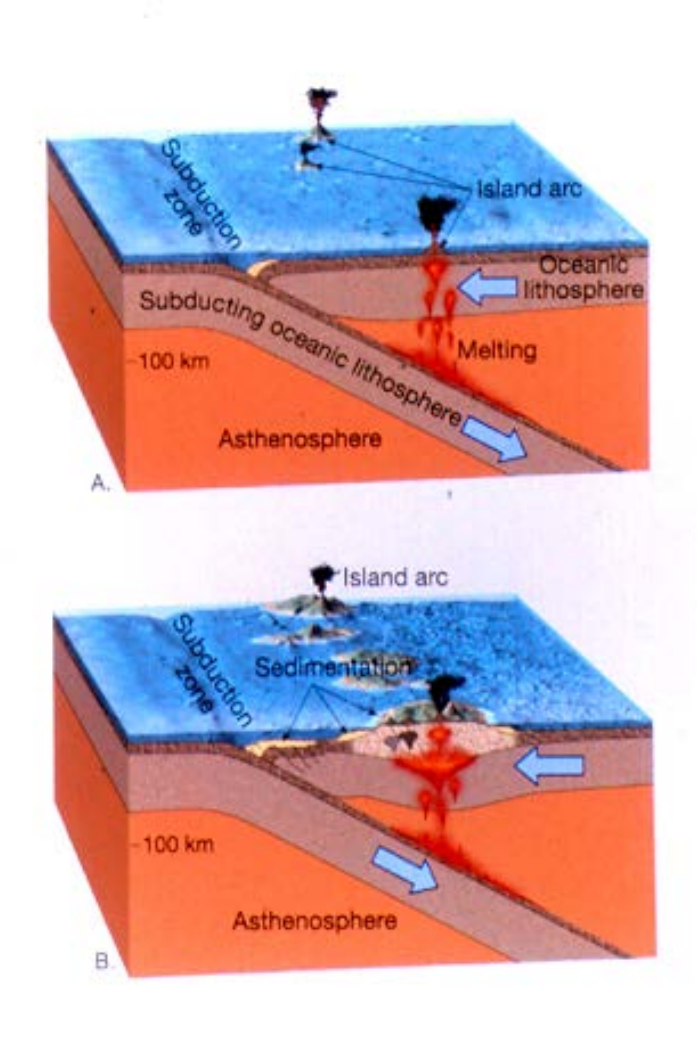
Timor





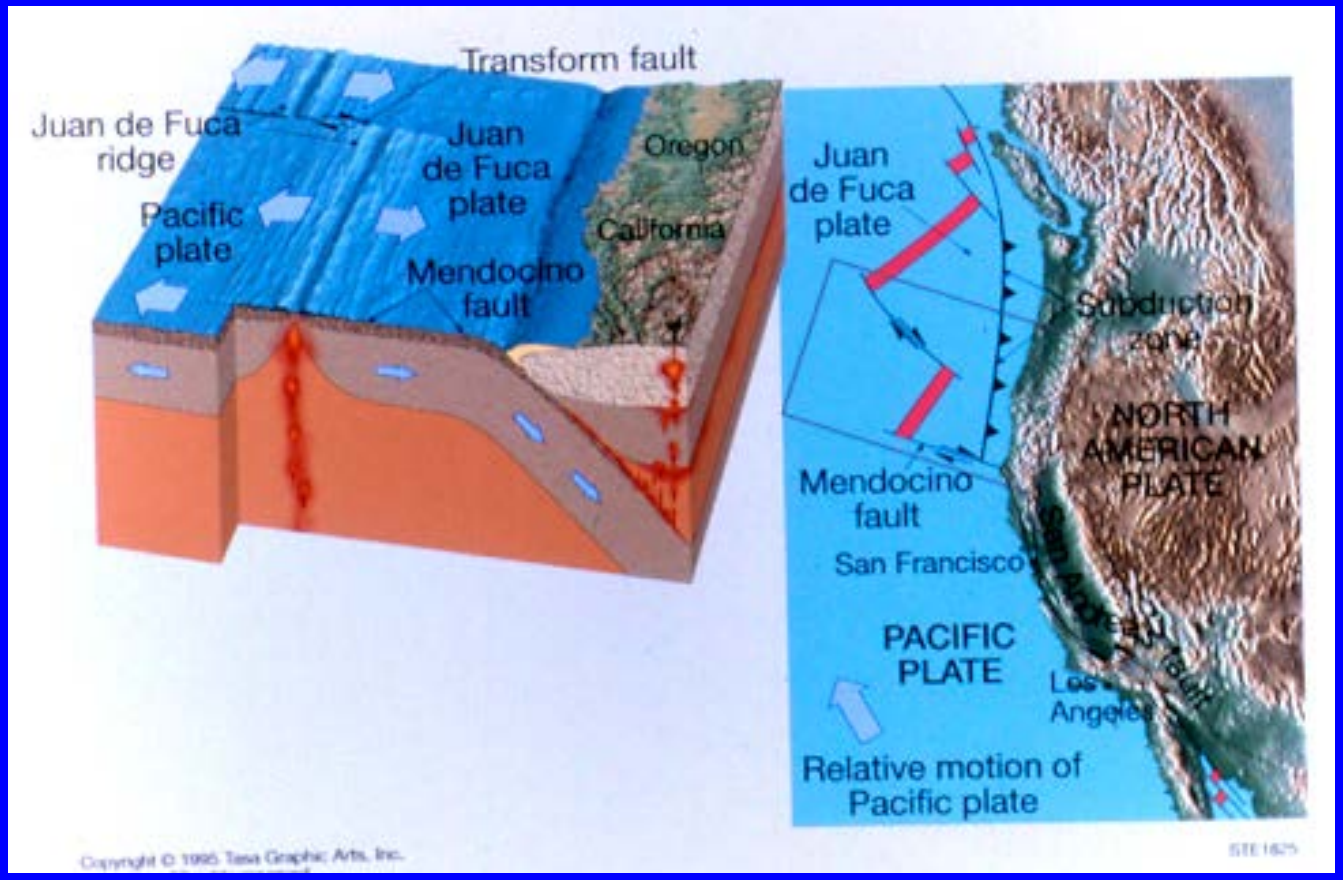
Kamchatka

More on subduction zones



Where oceanic crust is subducted beneath oceanic crust, melting of the slab produces volcanic **island arcs**

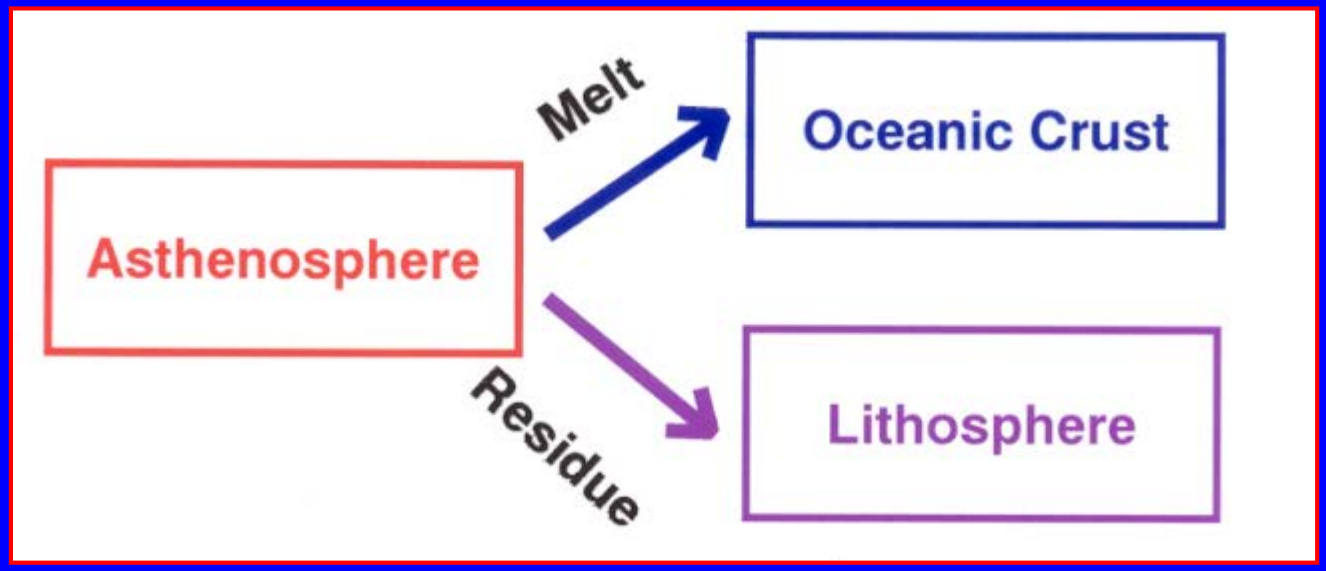
Subduction along the Washington - Oregon coast



Where oceanic crust is subducted beneath continental crust, melting of the slab produces a volcanic chain along the edge of the continent.

The Plate Tectonics Theory

- New lithosphere and oceanic crust is created at ocean ridges by melting of the asthenosphere.



- Convection in the asthenosphere drives the lithosphere and crust as rigid blocks or **PLATES** around the surface of the earth.
- Lithosphere (and oceanic crust) descend back into the mantle at the oceanic trenches. These are called **Subduction Zones.**

PLATE TECTONICS

=

CONTINENTAL DRIFT

+

SEA-FLOOR SPREADING

+

SUBDUCTION

Theory of Plate Tectonics

The theory of plate tectonics was a revolution in the earth sciences that explained most of the major geological features of the earth's crust in a **single comprehensive theory.**

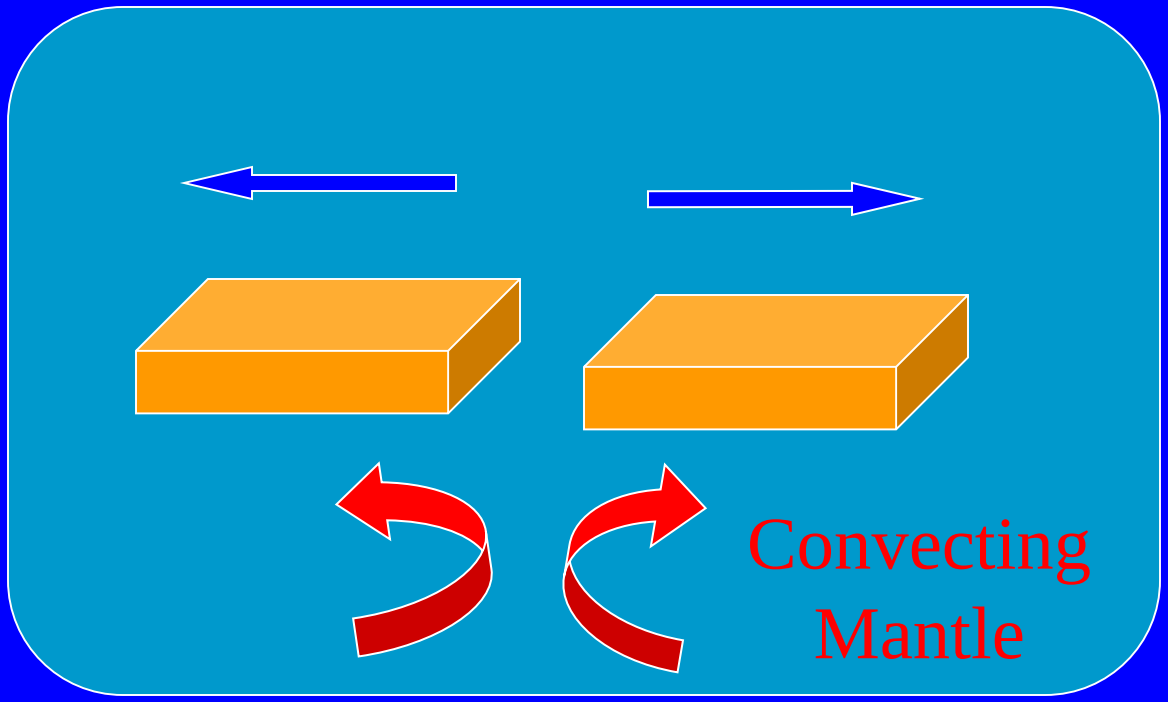
IT EXPLAINED:-

- The history of continents and ocean basins.
- Location of earthquake zones.
- Location of mountain ranges and mountain building.
- The location and origin of volcanoes.

There are three basic types of plate margins:-

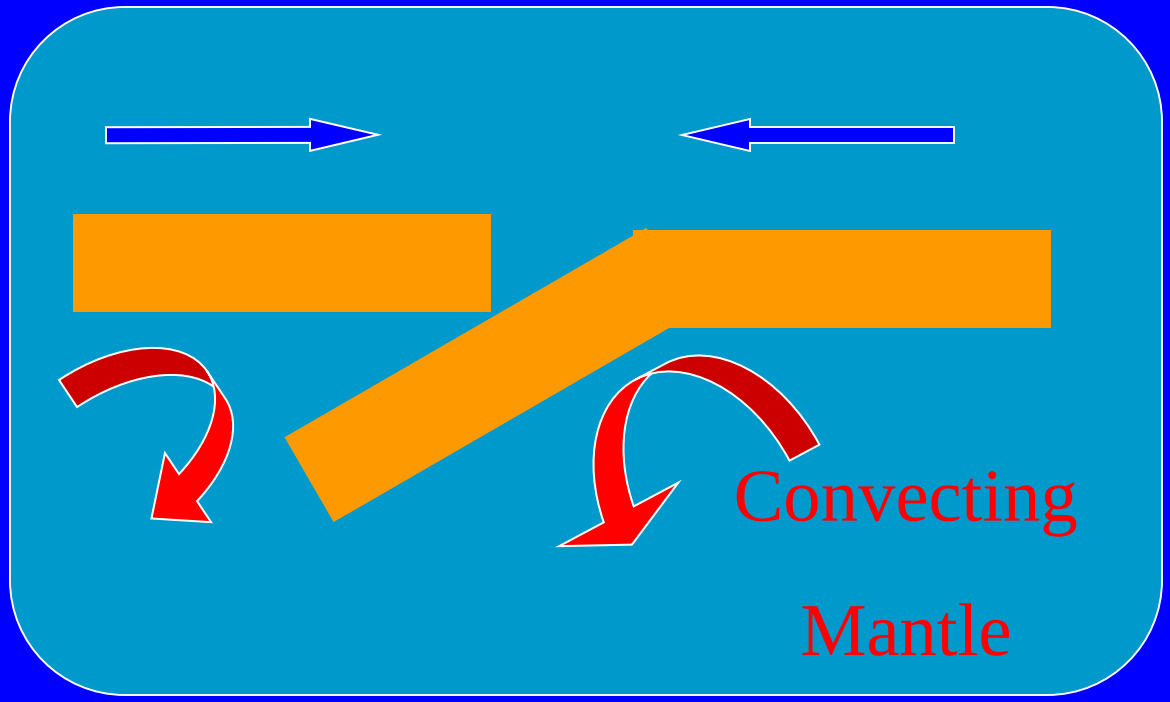
1) SPREADING
2) CONVERGING
3) TRANSFORM

SPREADING - plates move apart at ocean ridges or split continents apart



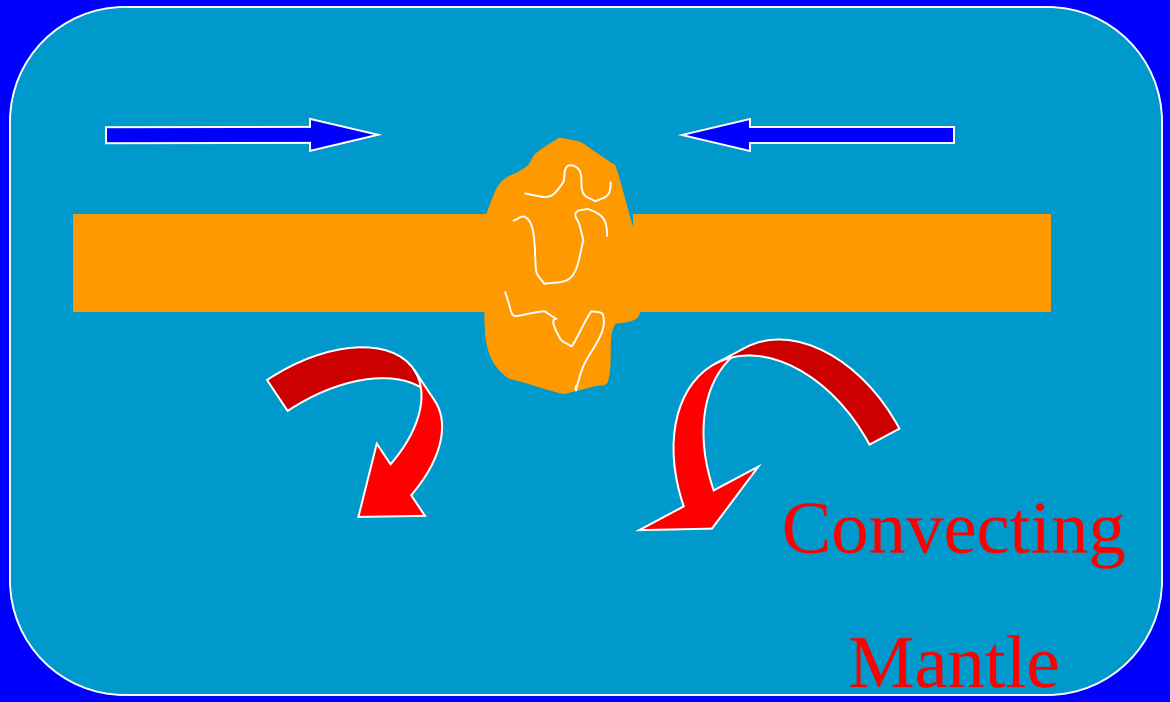
- Volcanoes
- Earthquakes

CONVERGING - plates either slip under one another to produce subduction zones or collide to form mountain ranges.



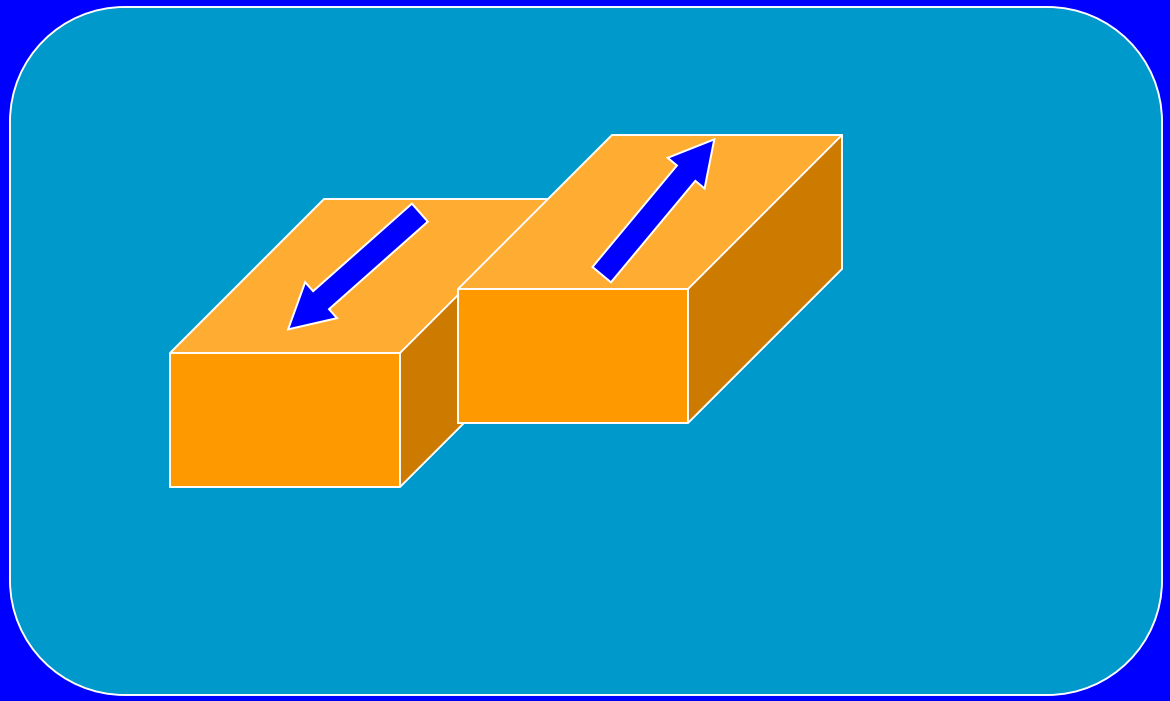
- Volcanoes
- Earthquakes

CONVERGING - plates crash together to Produce mountain ranges.



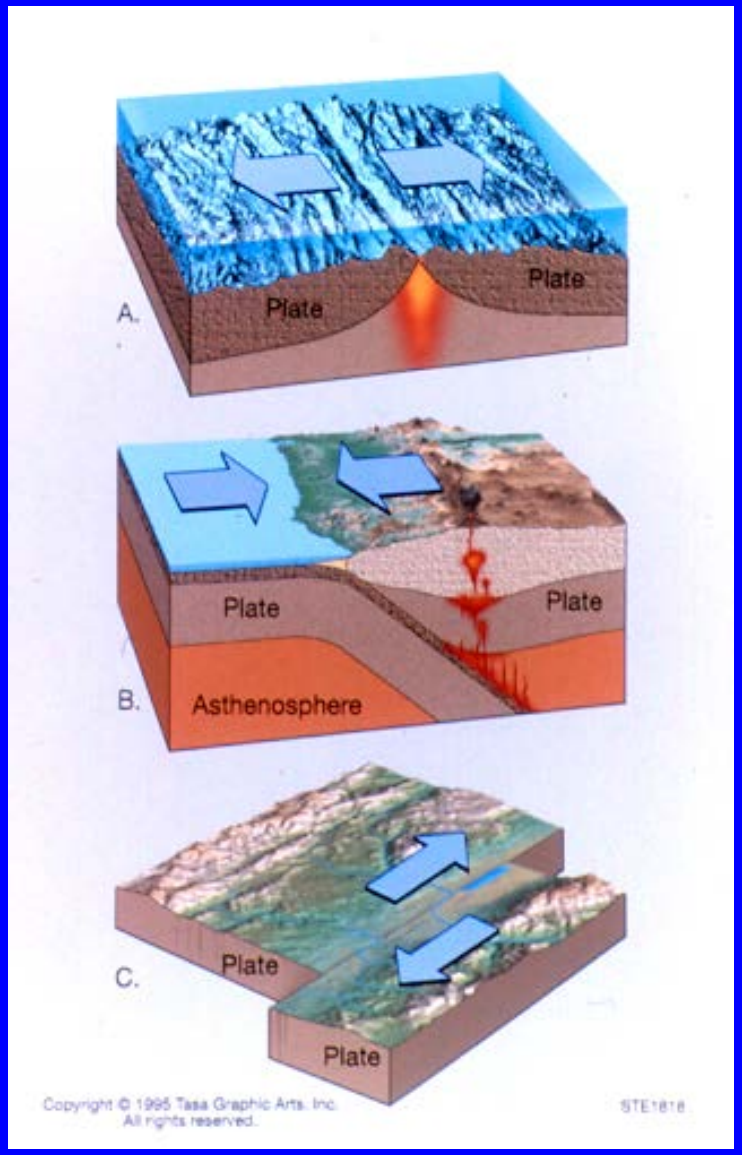
- Earthquakes
- Mountain ranges

TRANSFORM - plates slide horizontally past each other



Earthquakes only

Three types of plate margins

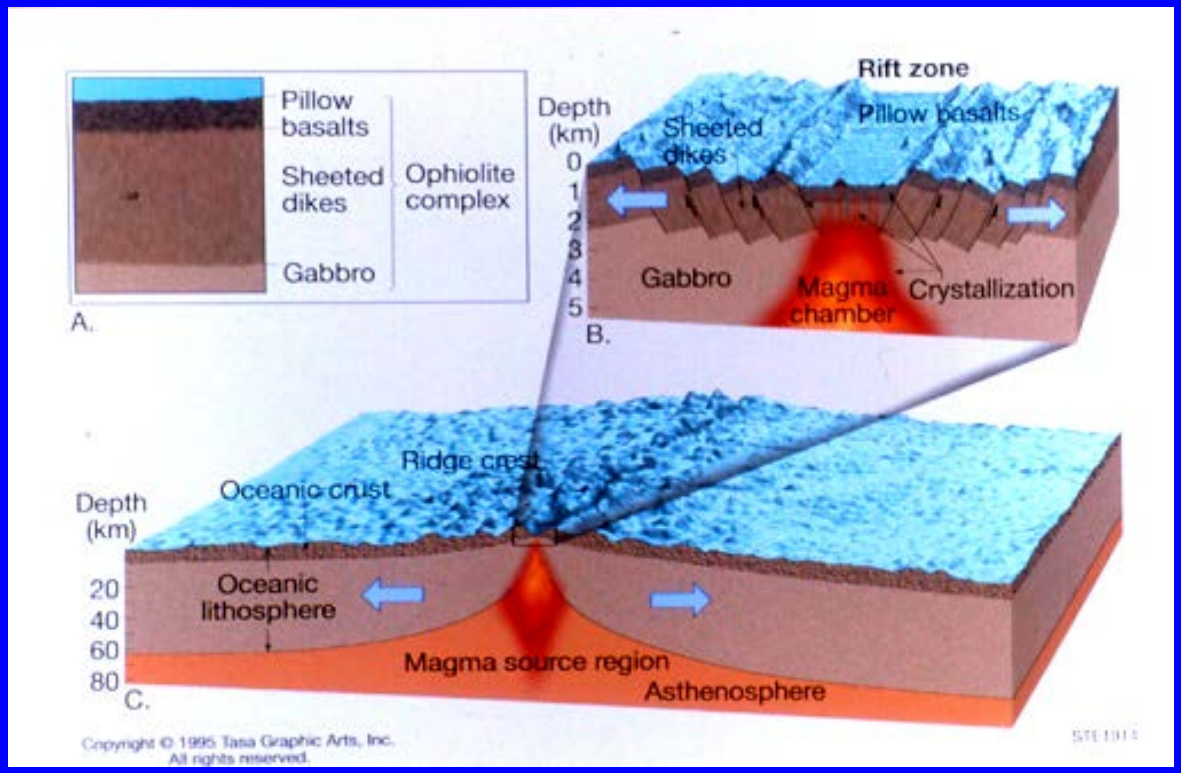


Spreading

Converging

Transform

Spreading Margins



Oceanic Crust

Pillow lavas (basalt)
Sheeted dikes
Gabbros

Earthquakes and Volcanoes

- Melting in the asthenosphere produces basaltic magma
- The magma moves upwards to form magma chambers in the crust.
- Magma erupts to produce new oceanic crust.

World-wide system of spreading ridges 65,000 km

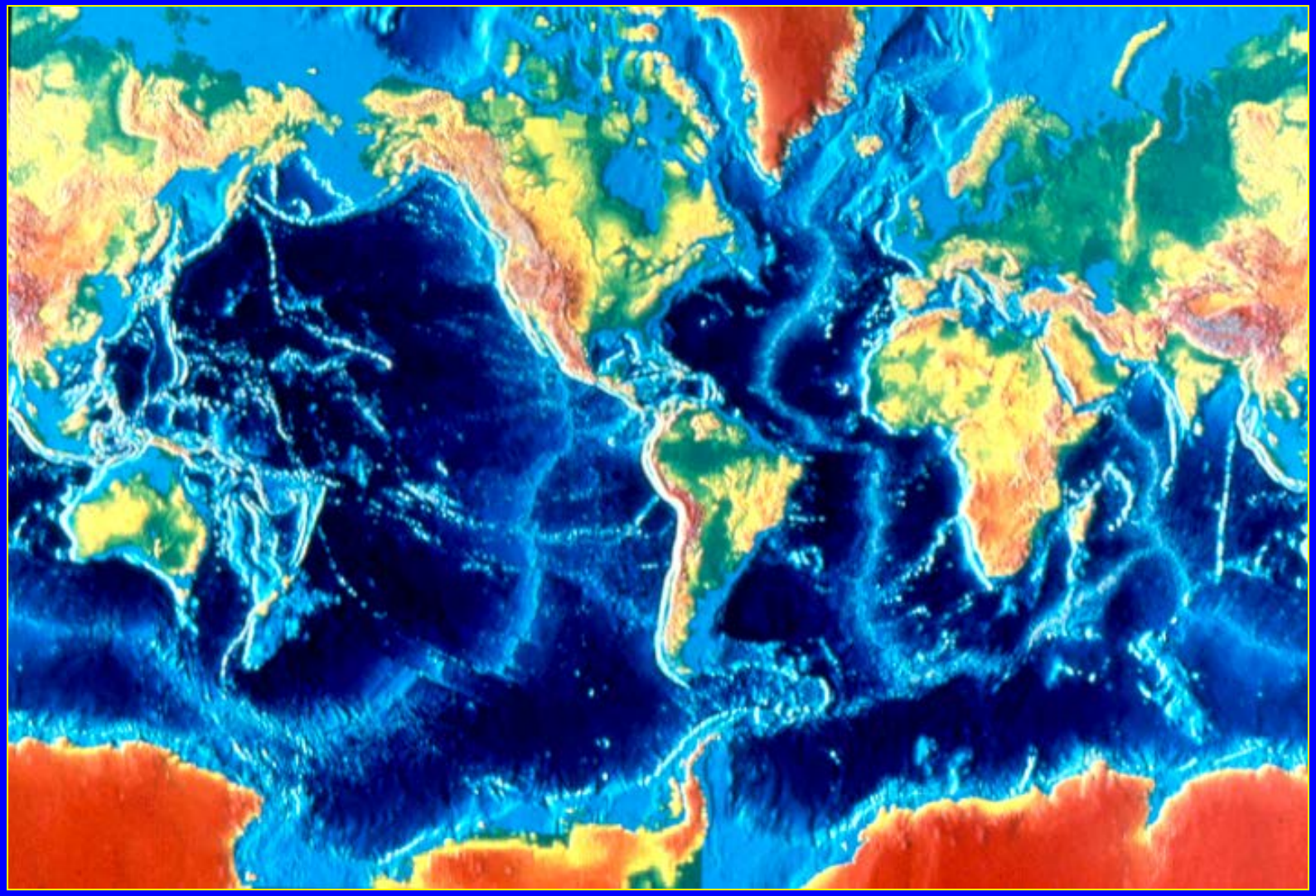
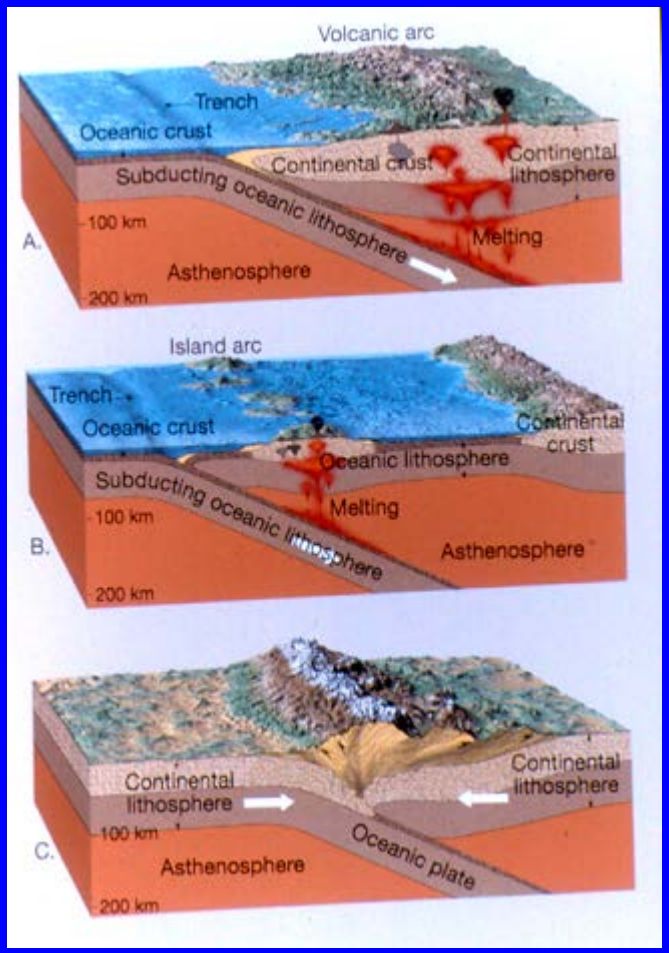


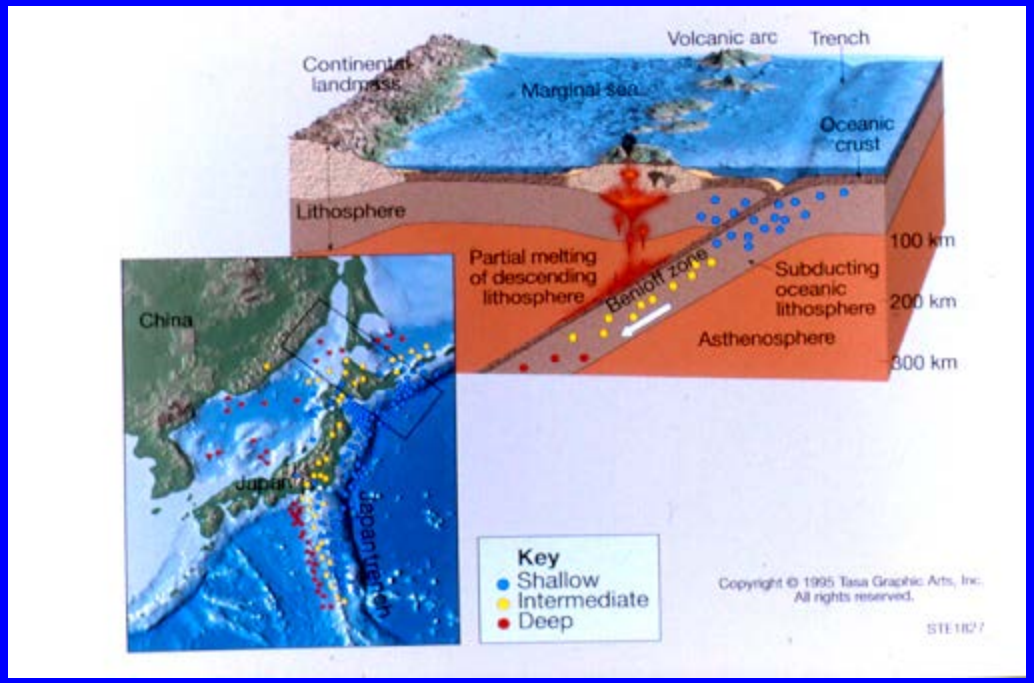
Plate Collision
(converging boundaries)

There are three basic types



- Ocean - Continent Collision
- Ocean-Ocean Collision
- Continent - Continent Collision

Ocean - Ocean Convergence

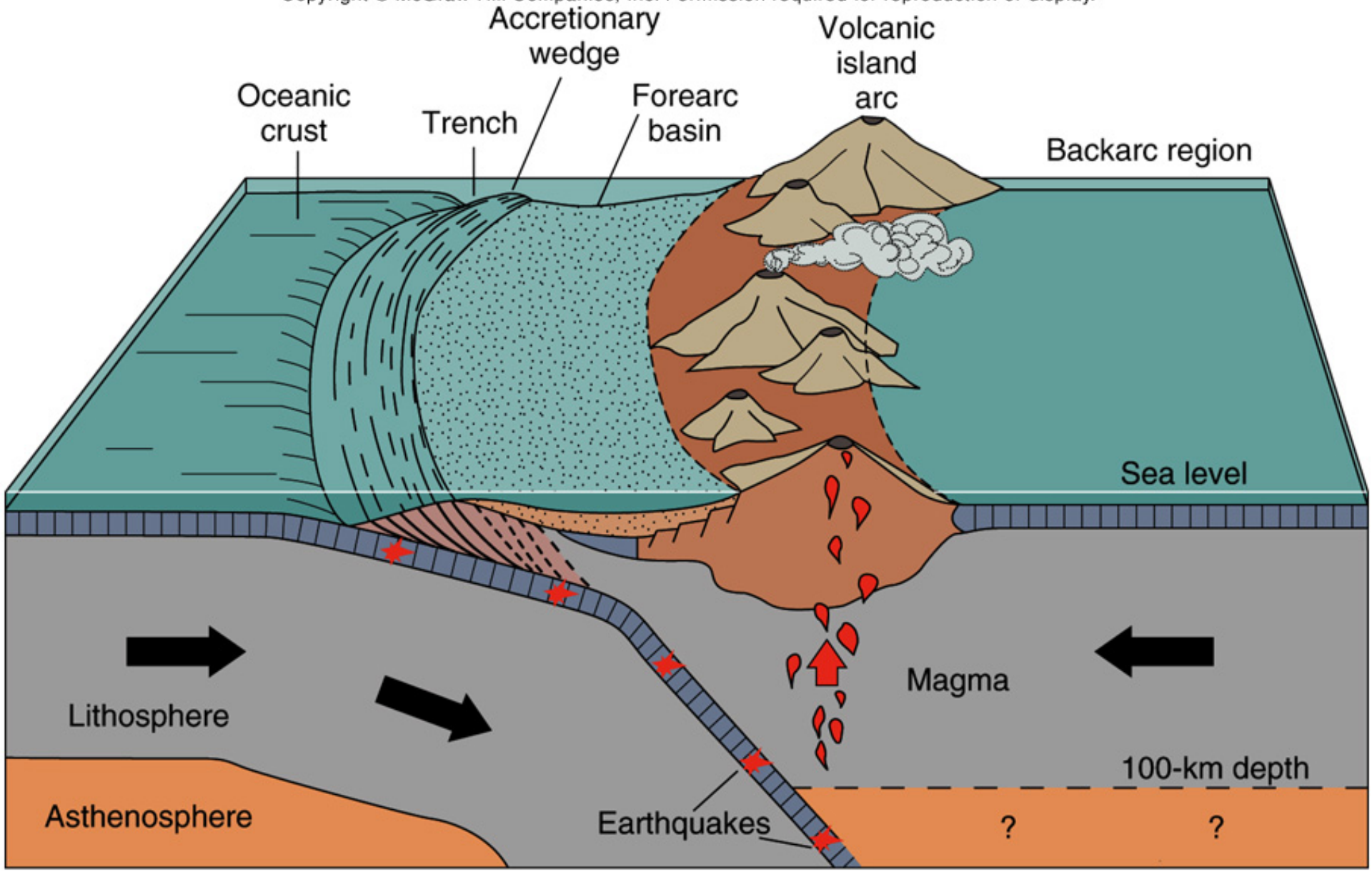


Examples

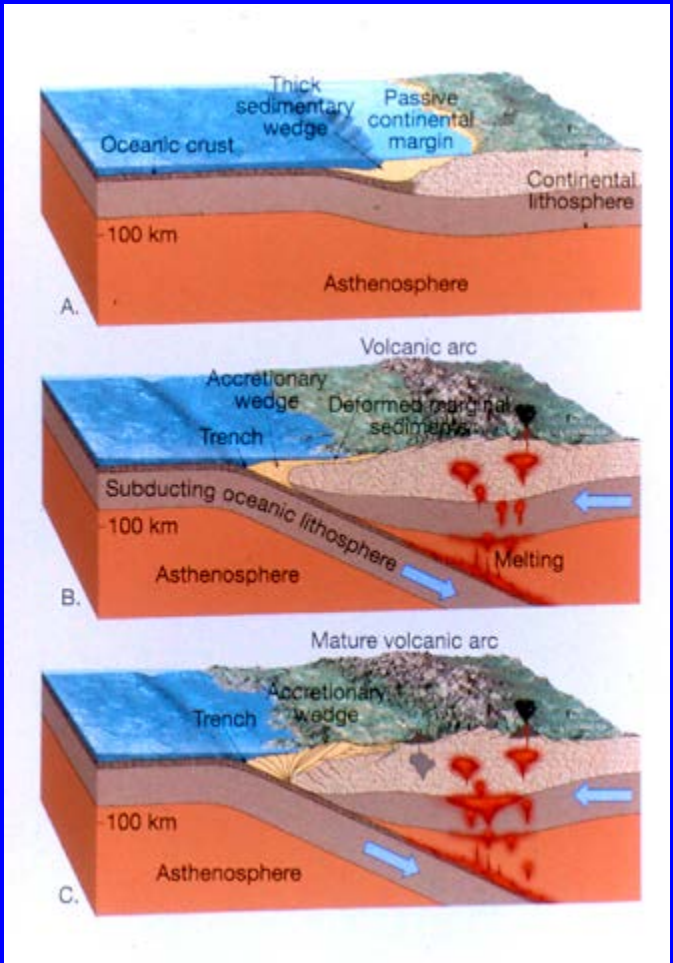
Japan
Aleutian Islands
Indonesia
Tonga - Fiji

Earthquakes and Volcanoes

An oceanic plate is subducted beneath another oceanic-plate, resulting in the formation of an oceanic trench and an island arc (Japan). Note earthquakes along the subducted slab (Benioff zone). The sea behind the arc (Japan Sea) is a Back-Arc Basin.



Ocean- Continent Convergence



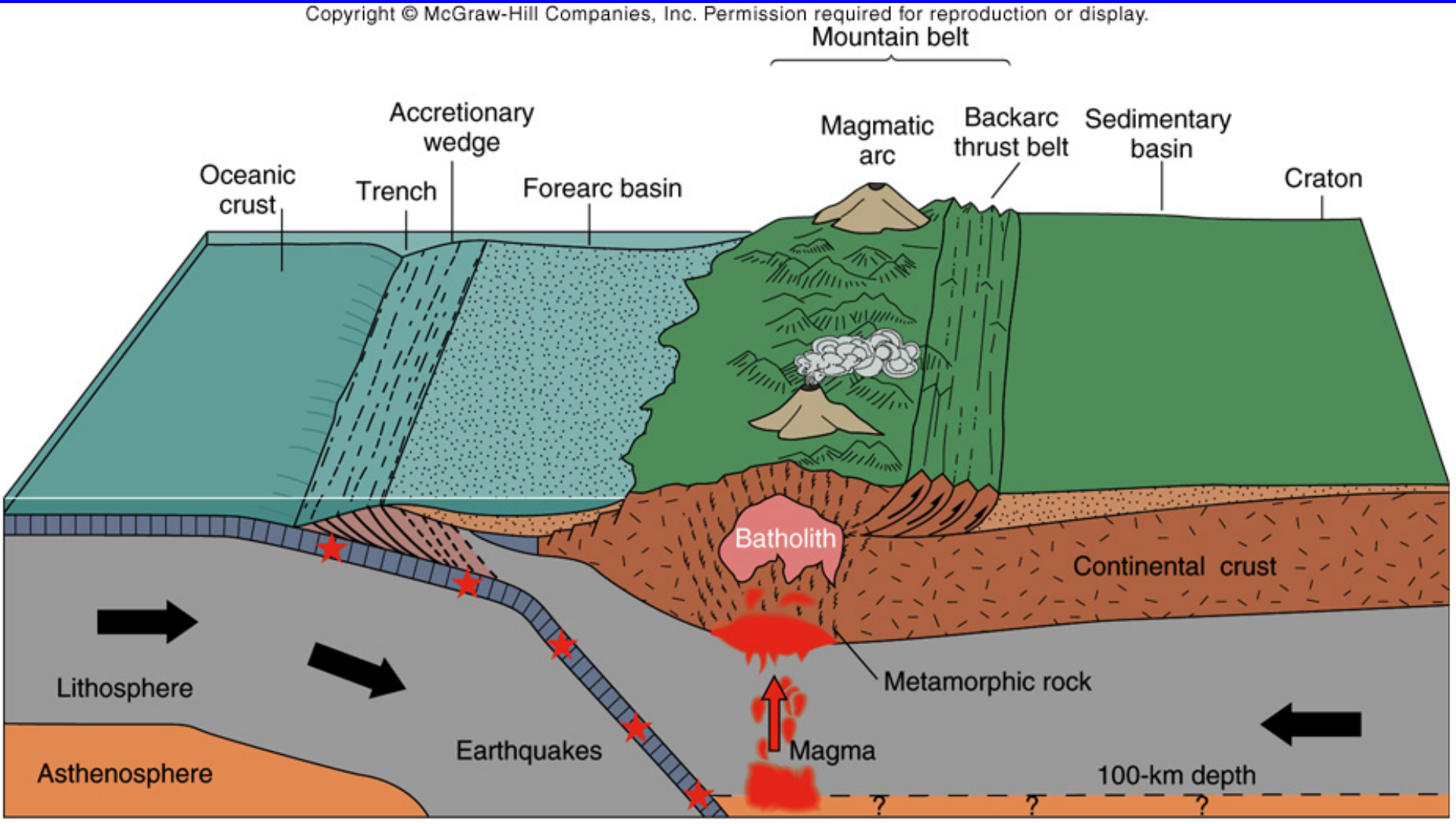
Earthquakes and Volcanoes

Dense oceanic crust is subducted beneath lighter Continental crust, resulting in the formation of an oceanic trench and a linear volcanic mountain range.

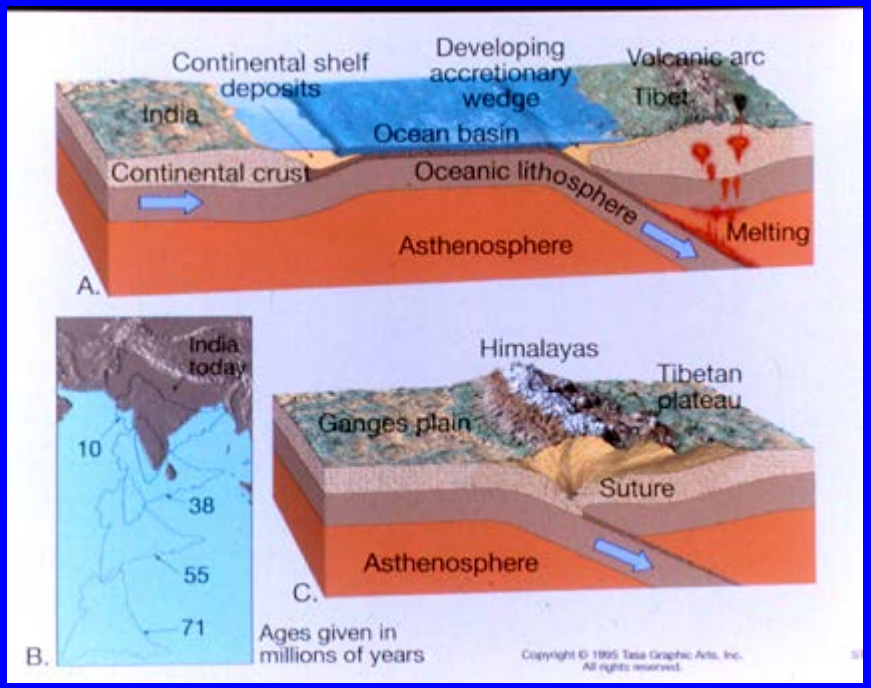
Melting occurs both in the down-going slab and in the crust producing large diversity of volcanic rocks. Also Earthquakes along the Benioff Zone.

Examples - Cascades and Andes

Page 98 in text



Continent- Continent Convergence



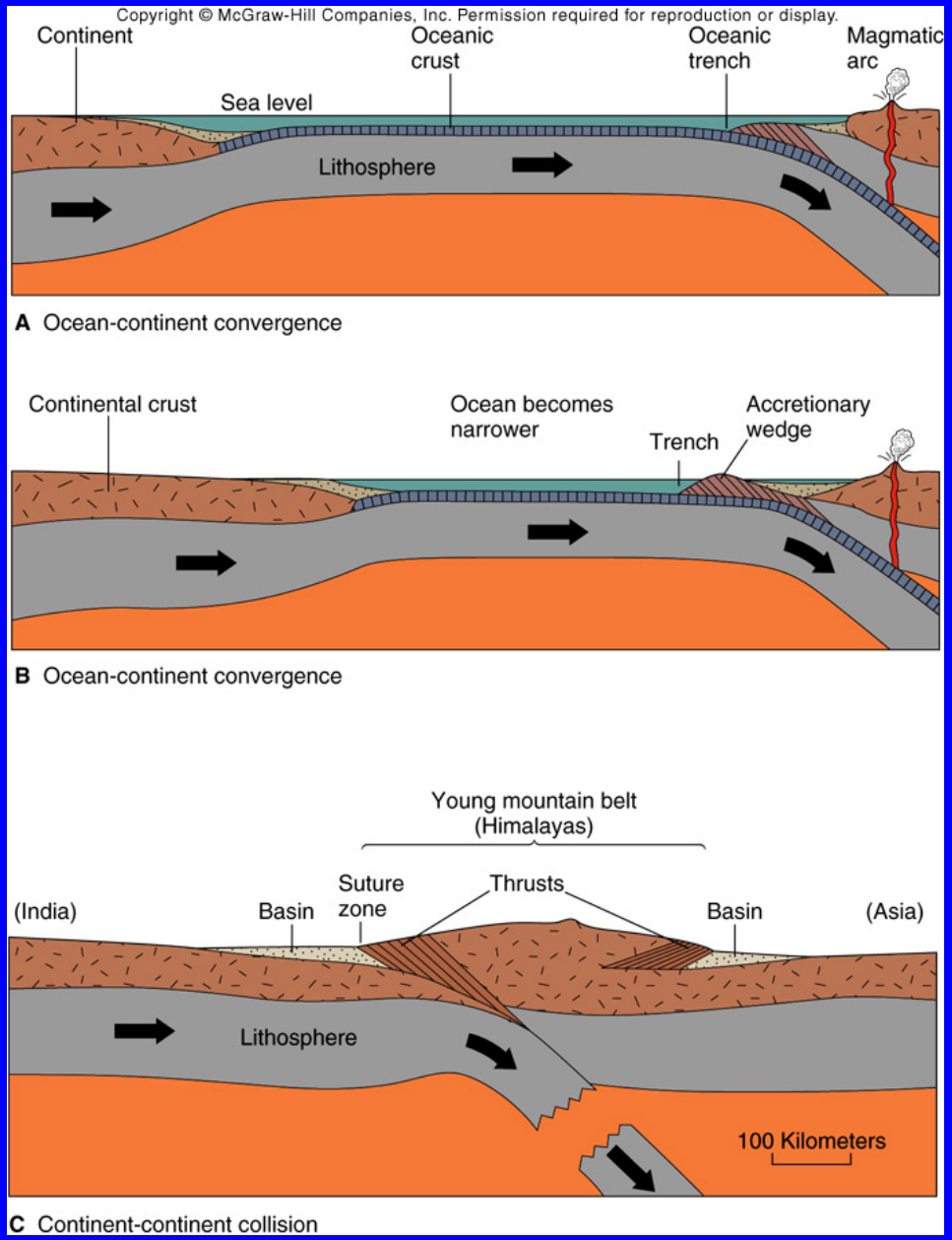
Examples

Himalayas
European Alps

Mountain Chains
Earthquakes
No Volcanoes

Starts as oceanic - continent subduction. Continental crust on the subducted plate is too light to be subducted. Consequently it crashes into the other continental crust, Squeezing and folding the sediments between them to produce a high mountain range.

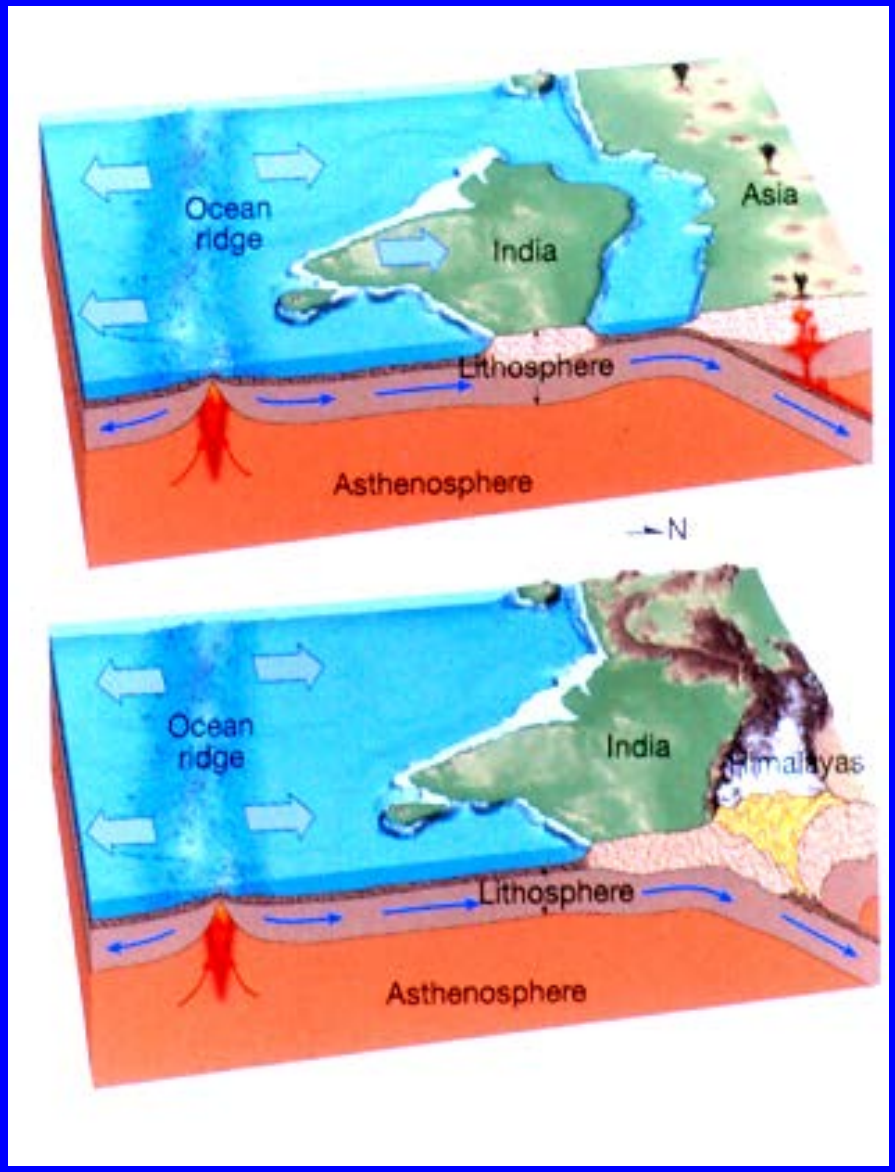
India Eurasia



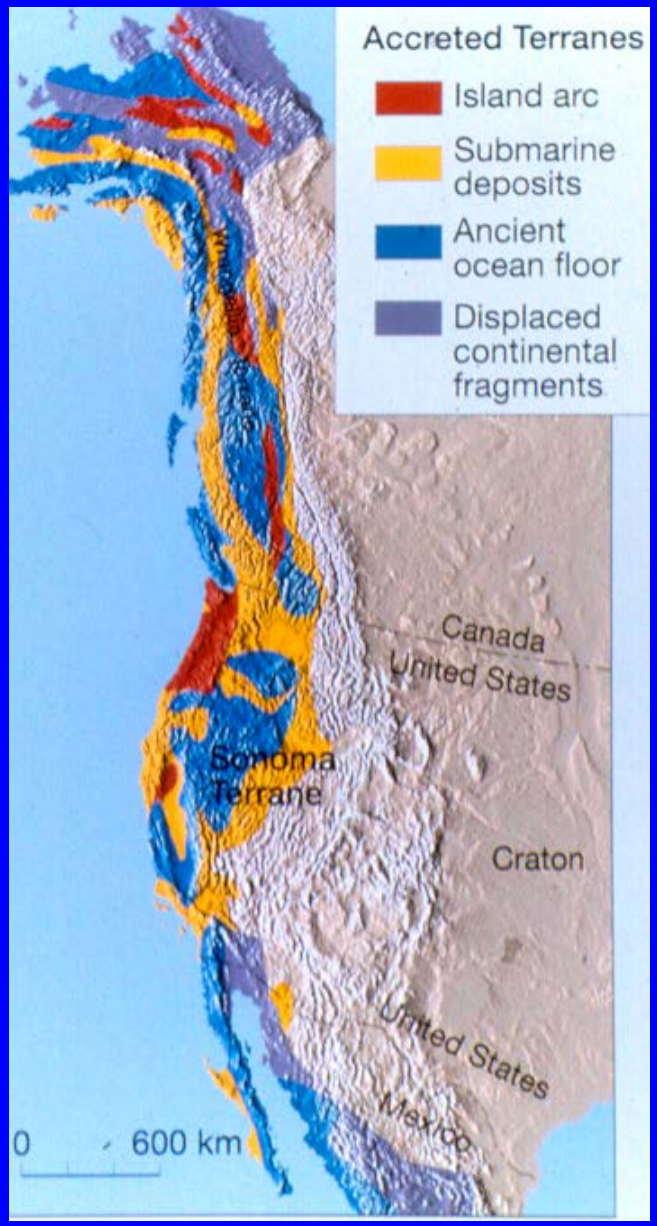
Sketch illustrating the convergence of India with Asia to produce the Himalayas

Page 100 in text

India crashes into Asia



Accreted Terranes



It follows that if continents collide, resulting in larger continental masses, smaller land-masses must also be colliding with continents.

This map shows different terranes that have accreted to western continental North America.

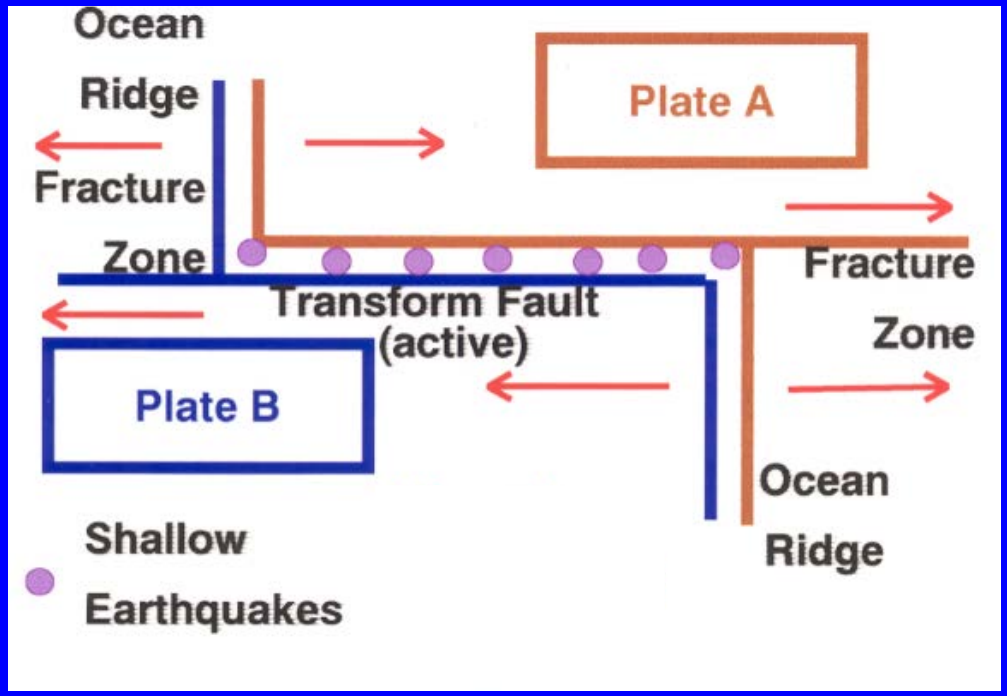
Each terrane (different colors) has different rock types, fossil types and paleomagnetic directions and inclinations, indicating that it came from somewhere else.

Transform Boundaries

- Transform boundaries occur where one segment of rigid lithosphere slides horizontally past another in response to stresses in the lithosphere.
- The oceanic ridge system is offset (or segmented) by many transform faults.
- Severe, shallow earthquakes are associated with transform boundaries.

Transform faults and fracture zones in the Atlantic Ocean

Explanation



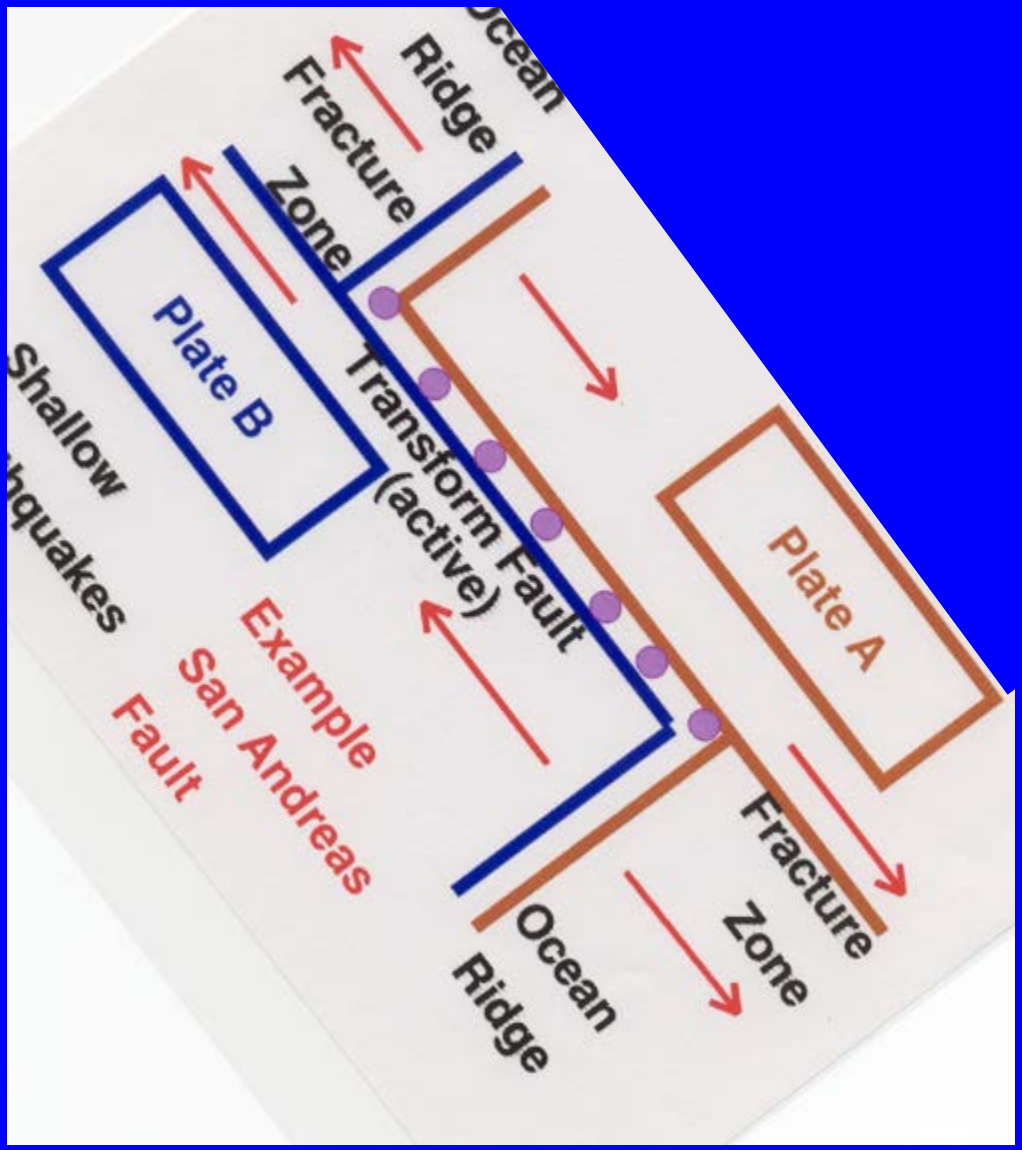
The San Andreas Fault is a transform fault linking the East Pacific Rise with the Gorda and Juan de Fuca Ridges.

Actually an inter-connecting fault system.

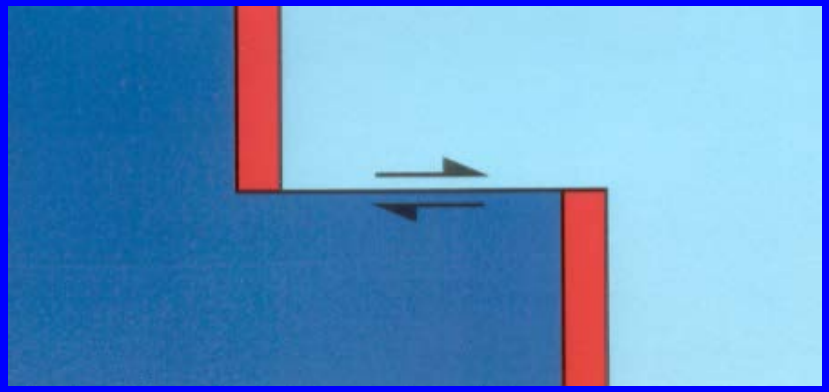
The west side is moving north relative to the east side.

Cause of numerous large shallow earthquakes.

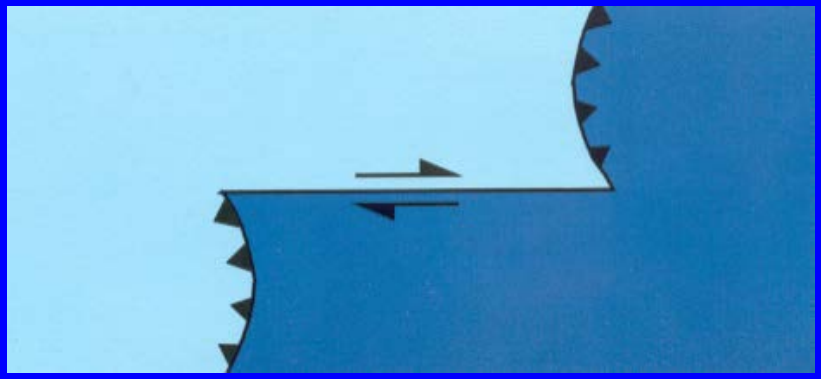
Rotating the previous sketch to show the movement of the San Andreas fault



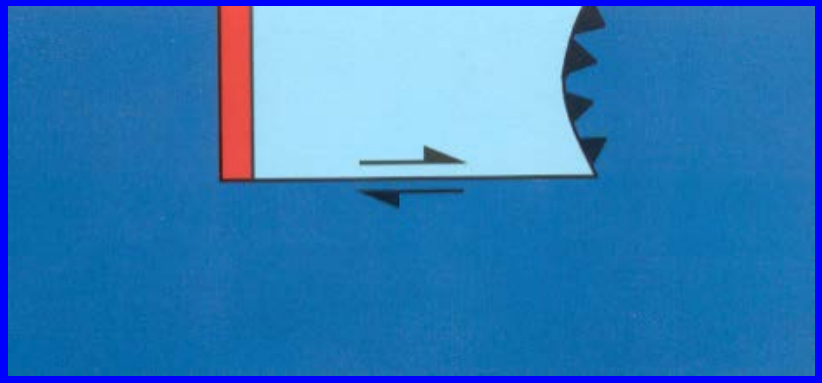
Not only do transform faults connect spreading ridges, but also ridges and trenches and two trenches.



Two ridges



Ridge and trench



Two trenches