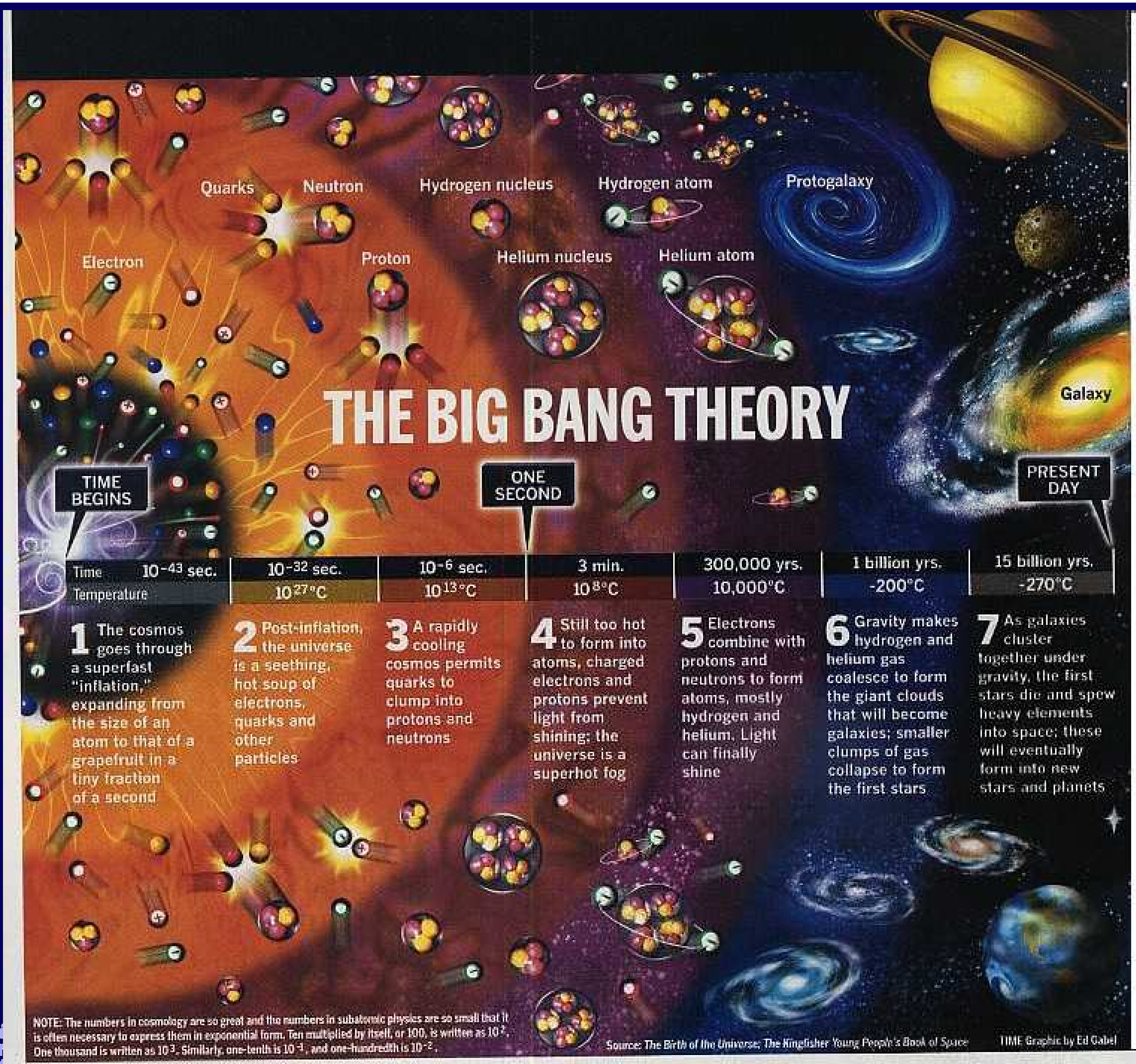
Earth Basics

1. **Earth Created 4.56 billion years ago (b.y.a.)**
   - Coincides with the creation of the solar system (4-5 b.y.a.)
   - Big Bang occurred 10-15 b.y.a.
2. Development of **Asthenosphere 4.0 b.y.a**.
   - **Asthenosphere:** upper most mantle underlying the lithosphere (more next)
3. Development of **Oceans 3.96 b.y.a.**
   - By 1.0 b.y.a. oceans on Earth resembled modern ocean chemistry



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Geologic Time

- "Deep" Time
  - Most geologic processes occur gradually over millions of years
  - Changes typically hardly noticeable over the span of a human lifetime
  - Current best estimate for age of Earth is ~4.56 *billion* years
- Geologic Time and the History of Life
  - Complex life forms first became abundant about 544 million years ago
  - Reptiles became abundant ~230 million years ago
  - Dinosaurs became extinct (along with *many* other organisms) ~65 million years ago
  - Humans have been around for a few million years
- "Nothing hurries geology"

Mark Twain

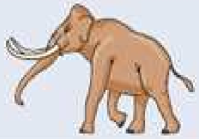
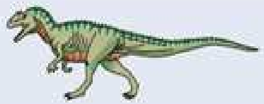
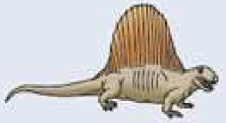
TABLE 1.2 Some Important Ages in the Development of Life on Earth

Millions of Years before Present	Noteworthy Life	Eras	Periods
4	Earliest hominids	Cenozoic	Quaternary
65	First important mammals Extinction of dinosaurs		Tertiary
	First dinosaurs	Mesozoic	Cretaceous Jurassic Triassic
251			
300	First reptiles	Paleozoic	Permian Pennsylvanian Mississippian
400	Fishes become abundant		Devonian Silurian Ordovician Cambrian
544	First abundant fossils		
600	Some complex, soft-bodied life	Precambrian	(The Precambrian accounts for the vast majority of geologic time.)
3,500	Earliest single-celled fossils		
4,550	Origin of the Earth		

Geologic Time: a 4.6 billion year old Earth

Era	Period		Epoch	Millions of years ago
Cenozoic	Quaternary		Holocene	0.01
			Pleistocene	1.8
	Tertiary		Pliocene	5.3
			Miocene	23.8
			Oligocene	33.7
			Eocene	54.8
			Paleocene	65.0
Mesozoic	Cretaceous			144
	Jurassic			206
	Triassic			248
Paleozoic	Permian			290
	Carboniferous	Pennsylvanian		323
		Mississippian		354
	Devonian			417
	Silurian			443
	Ordovician			490
	Cambrian			540
Precambrian				

TABLE 1.2 Some Important Ages in the Development of Life on Earth

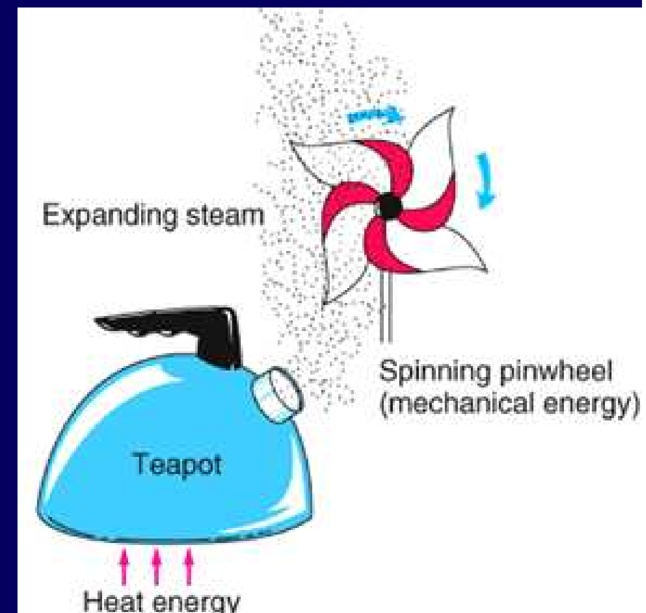
Millions of Years before Present	Noteworthy Life		Eras	Periods
4	Earliest hominids		Cenozoic	Quaternary, Tertiary
65	First important mammals			
	Extinction of dinosaurs			
	First dinosaurs		Mesozoic	Cretaceous, Jurassic, Triassic
251				
300	First reptiles		Paleozoic	Permian, Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, Cambrian
400	Fishes become abundant			
544	First abundant fossils			
600	Some complex, soft-bodied life		Precambrian	(The Precambrian accounts for the vast majority of geologic time.)
3,500	Earliest single-celled fossils			
4,550	Origin of the Earth			

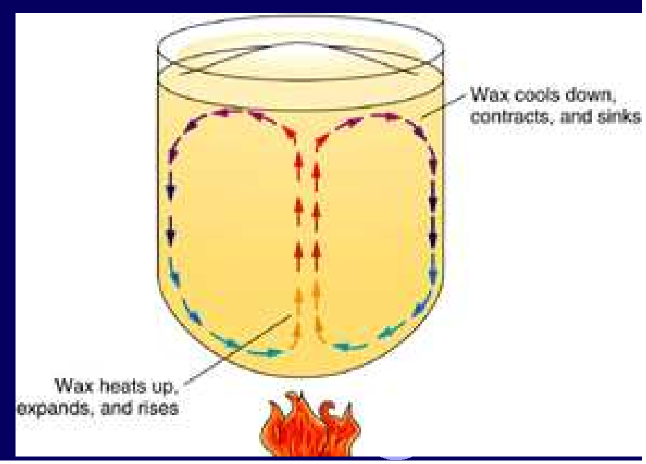
Physical Geology Concepts

- Earth’s Systems
  - *Atmosphere*
    - the gases that envelop the Earth
  - *Hydrosphere*
    - water on or near the Earth’s surface
  - *Biosphere*
    - all living or once-living materials
  - *Geosphere*
    - the solid rocky Earth

Physical Geology Concepts

- *Earth's Heat Engines*
  - External (energy from the Sun)
    - Primary driver of atmospheric (weather) and hydrospheric (ocean currents) circulation
    - Controls weathering of rocks at Earth's surface
  - Internal (heat moving from hot interior to cooler exterior)
    - Primary driver of most geospheric phenomena (volcanism, tectonism)





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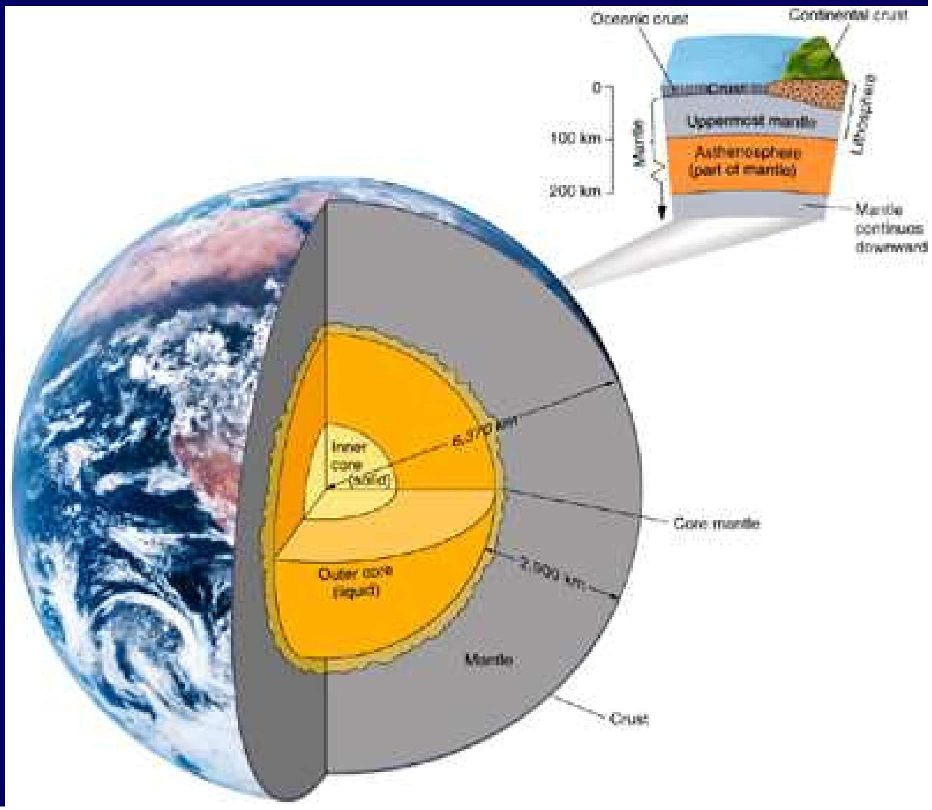
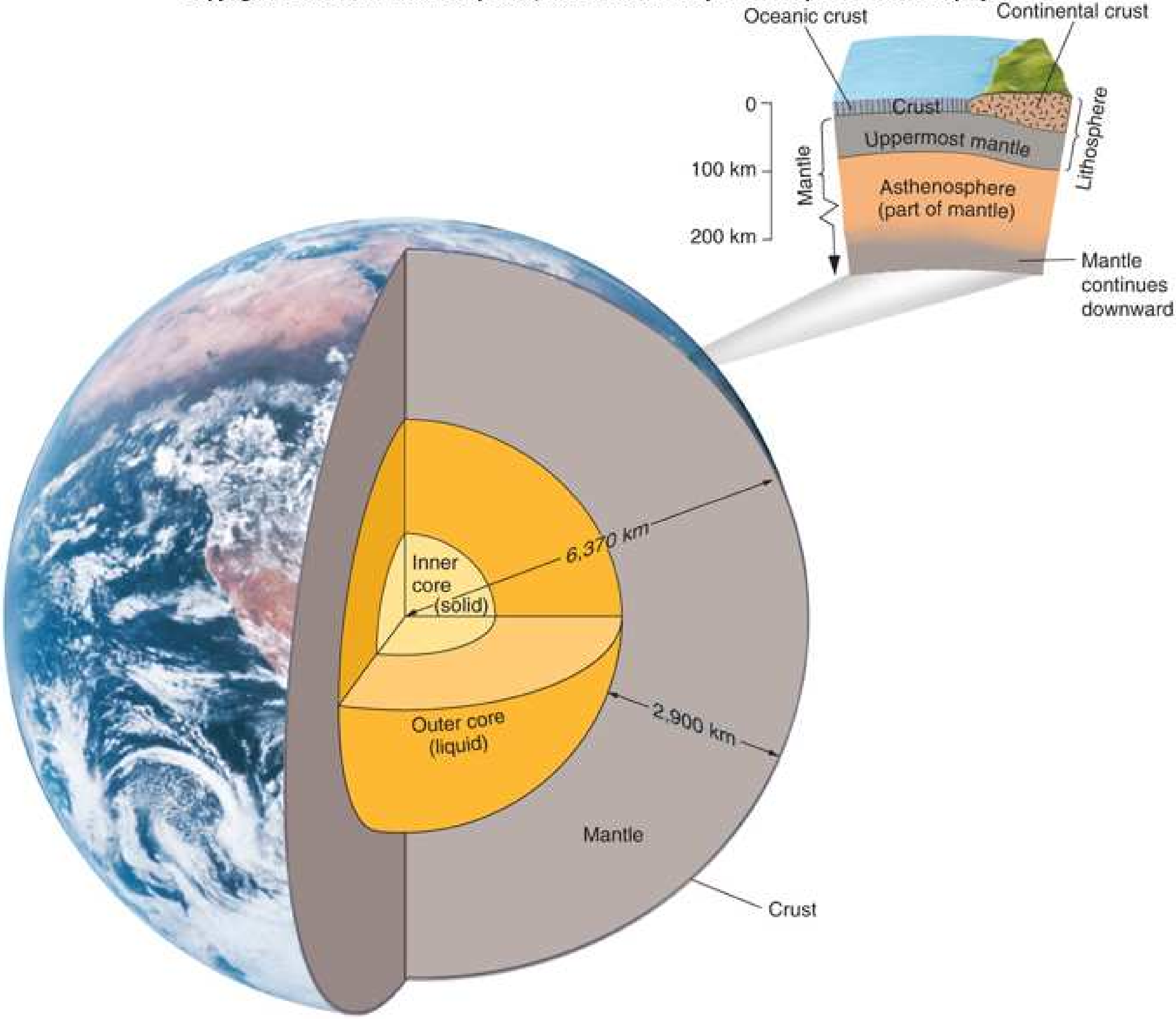
Earth's Interior

Compositional Layers

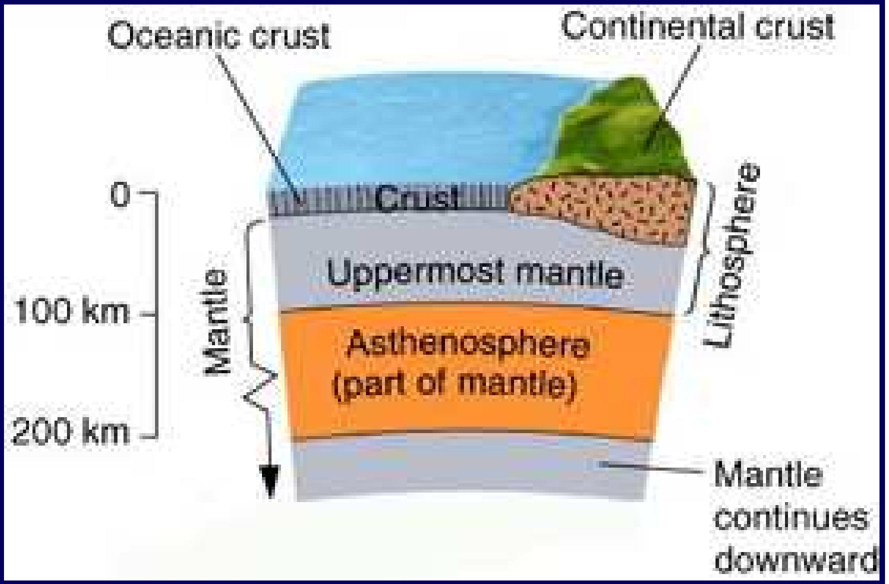
- ***Crust*** (~3-70 km thick)
  - Very thin outer rocky shell of Earth
    - Continental crust - thicker and less dense
    - Oceanic crust - thinner and more dense
- ***Mantle*** (~2900 km thick)
  - Hot solid that flows slowly over time; Fe-, Mg-, Si-rich minerals
- ***Core*** (~3400 km radius)
  - Outer core - metallic liquid; mostly iron
  - Inner core - metallic solid; mostly iron




Oceanic crust
Continental crust
0
100 km
200 km
Mantle
Crust
Uppermost mantle
Lithosphere
Asthenosphere
(part of mantle)
Mantle
continues
downward
Inner
core
(solid)
6,370 km
Outer core
(liquid)
2,900 km
Mantle
Crust

Earth's Interior

- Mechanical Layers
  - ***Lithosphere*** (~100 km thick)
    - Rigid/brittle outer shell of Earth
    - Composed of both crust and uppermost mantle
    - Makes up Earth's tectonic "plates"
  - ***Asthenosphere***
    - Plastic (capable of flow) zone on which the lithosphere "floats"



Internal Processes:

How the Earth's Internal Heat Engine Works

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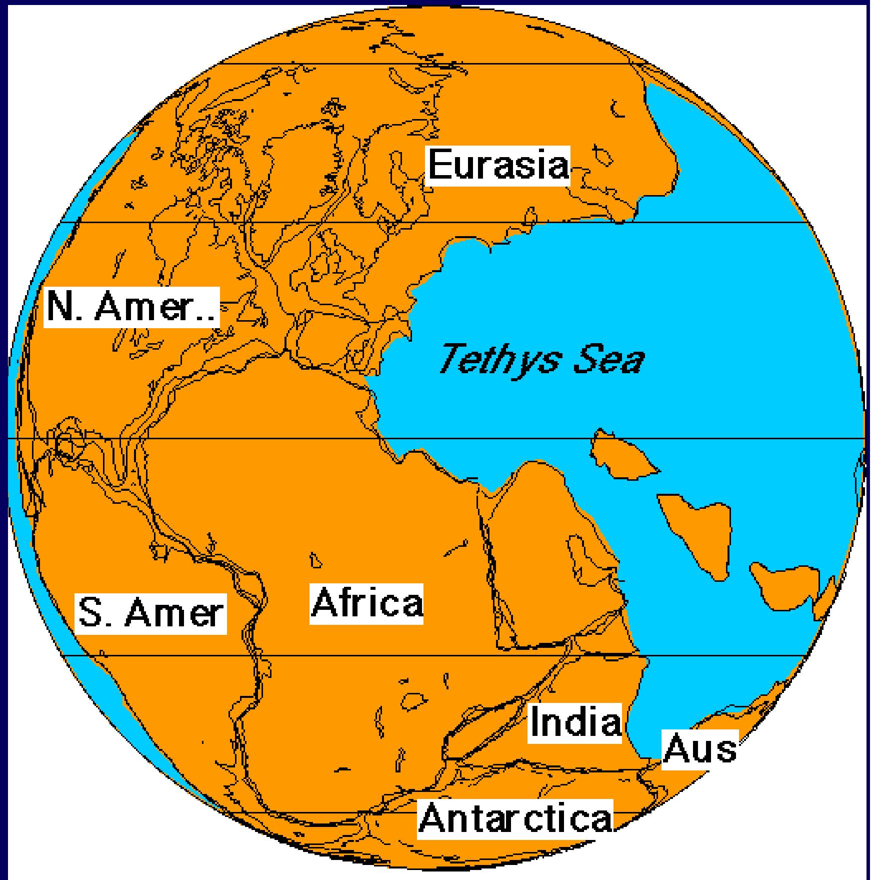
University of New Orleans

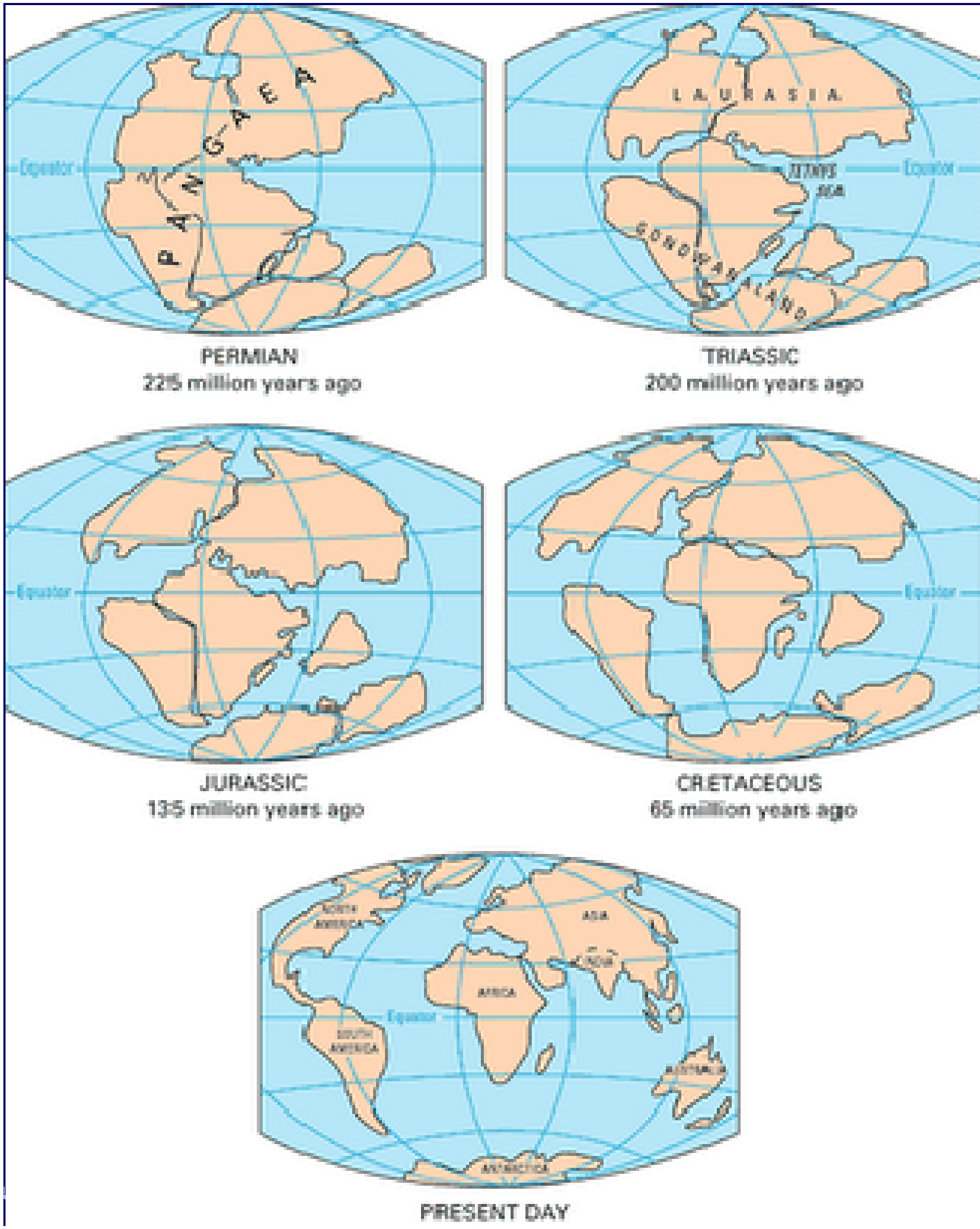
Theory of Plate Tectonics

Pangaea (meaning *Earth* in Ancient Greek) was the supercontinent that existed during the Paleozoic and Mesozoic eras about 250 million years ago, before the component continents were separated into their current configuration.

The name was first used by the German originator of the continental drift theory, Alfred Wegener, in the 1920 edition of his book *The Origin of Continents and Oceans*, in which a postulated supercontinent Pangaea played a key role.



Pangea 245 m.y.



Animation

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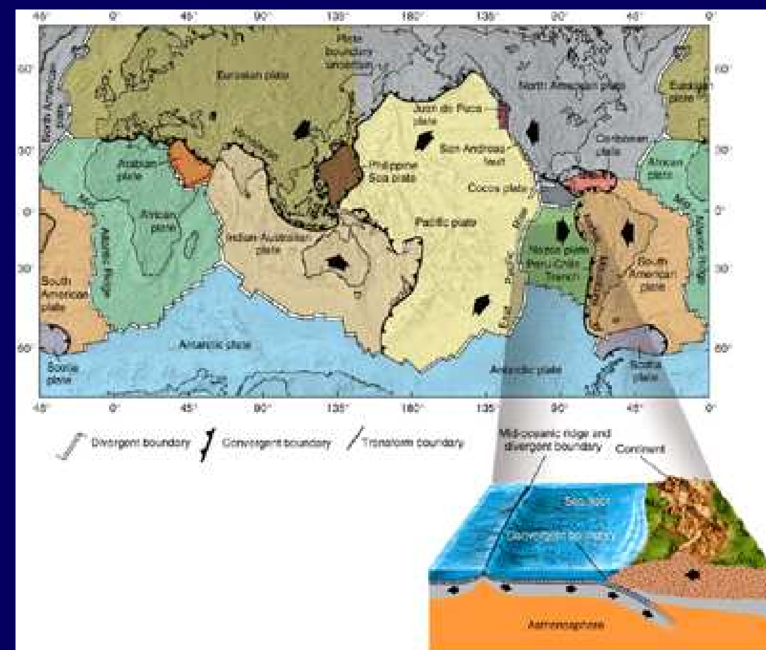
Theory of Plate Tectonics

- *Continental Drift Hypothesis*
  - Originally proposed in early 20th century to explain the "fit of continents", matching rock types and fossils across ocean basins, etc.
  - Insufficient evidence found for driving mechanism; *hypothesis initially rejected*
- *Plate Tectonics Theory*
  - Originally proposed in the late 1960s
  - Included new understanding of the seafloor and explanation of driving force
  - Describes lithosphere as being broken into *plates* that are in motion **(1-18cm/year)**
  - Explains origin and distribution of volcanoes, fault zones and mountain belts



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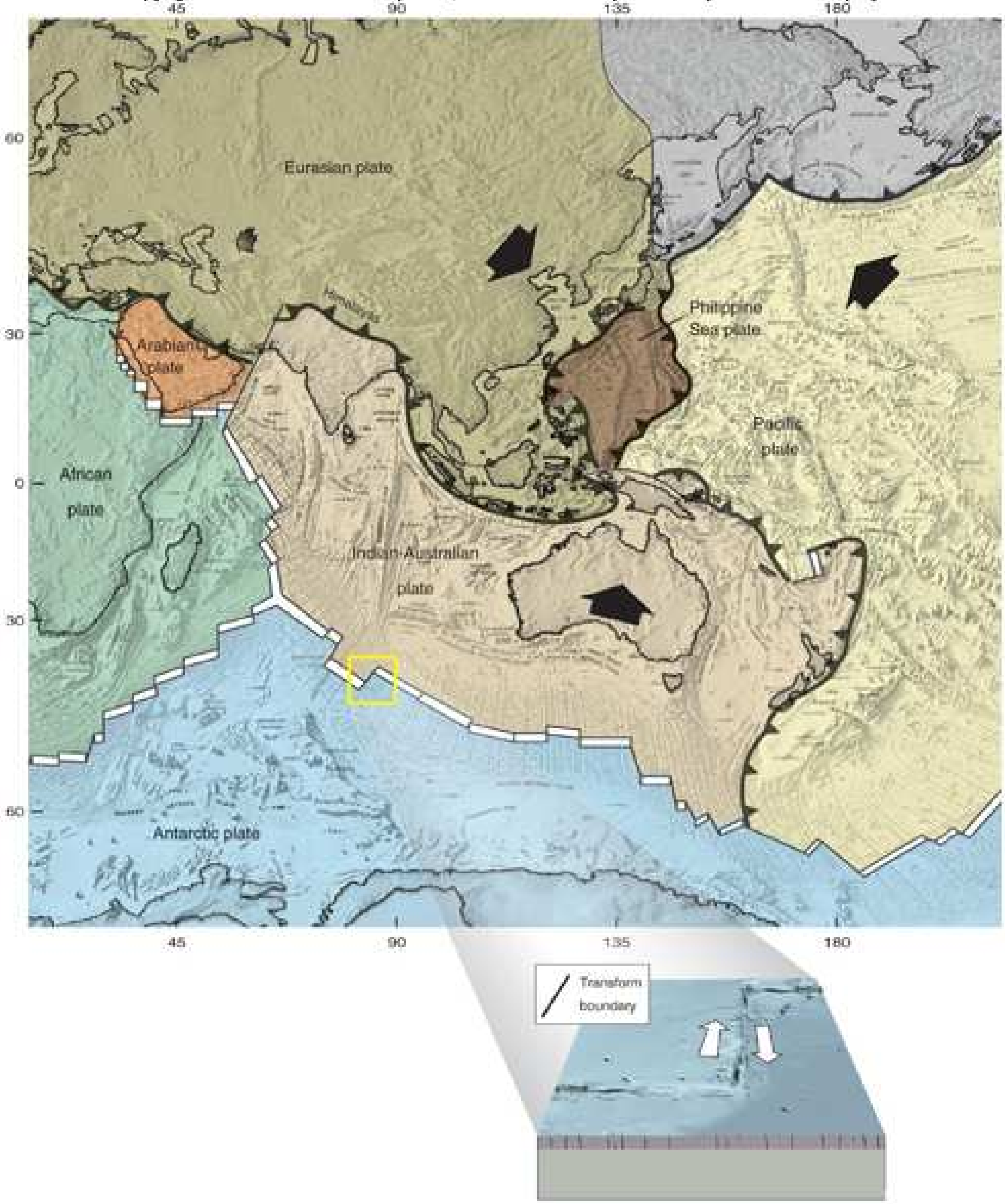
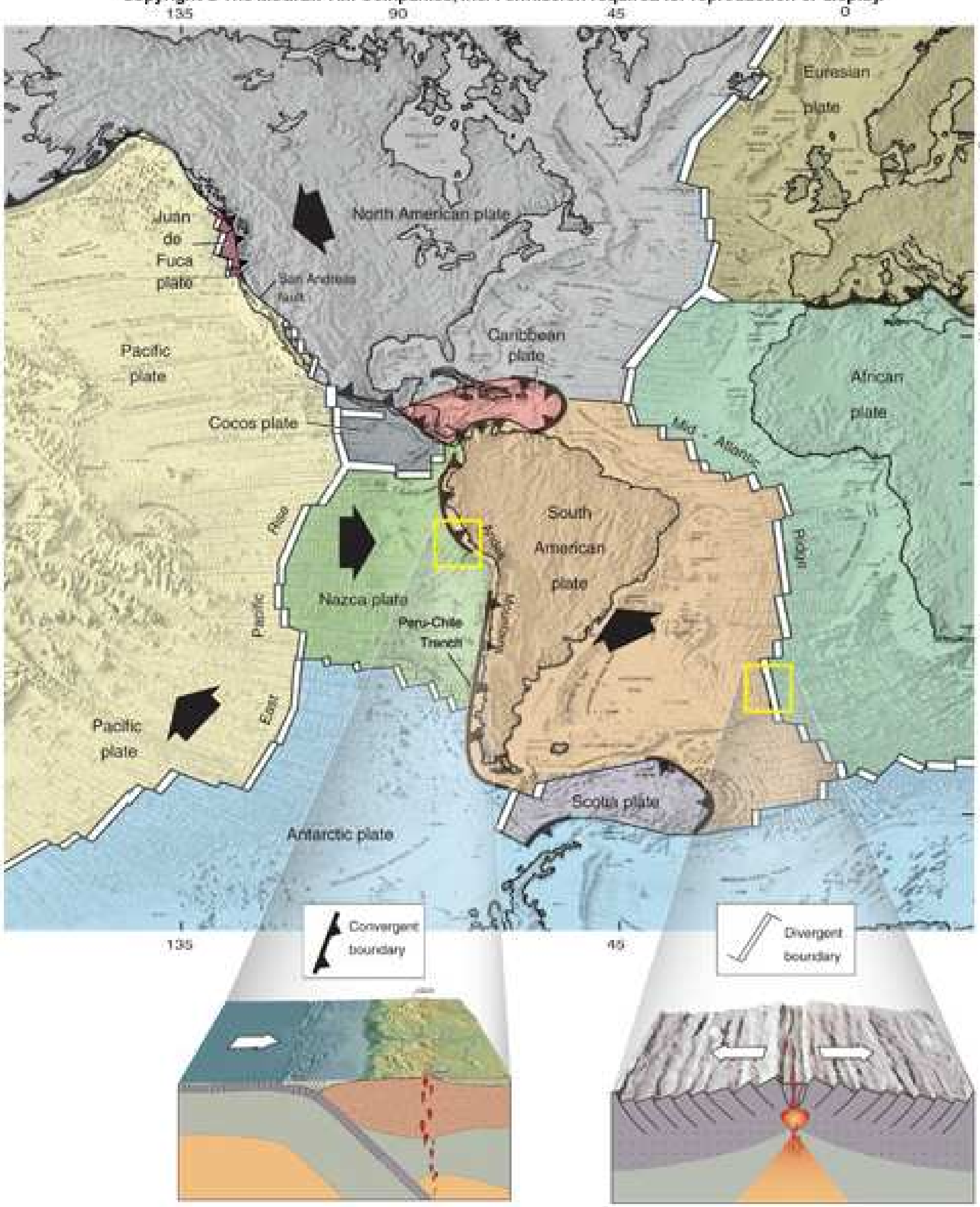

45
90
135
180
60
30
0
30
60
Eurasian plate
Philippine
Sea plate
Arabian
plate
African
plate
Pacific
plate
Indian-Australian
plate
Antarctic plate
Transform
boundary



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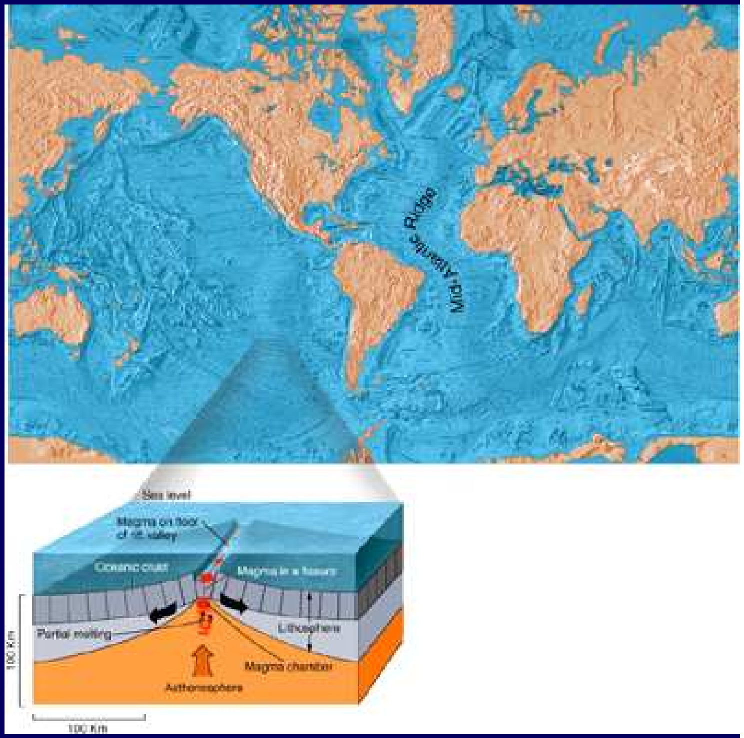
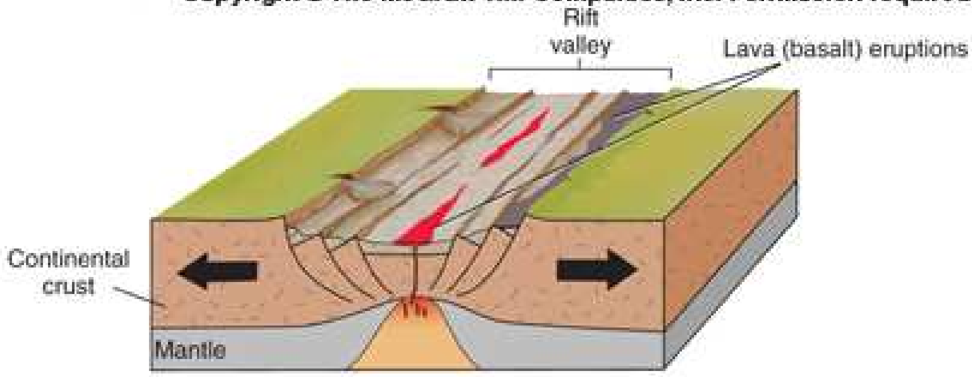
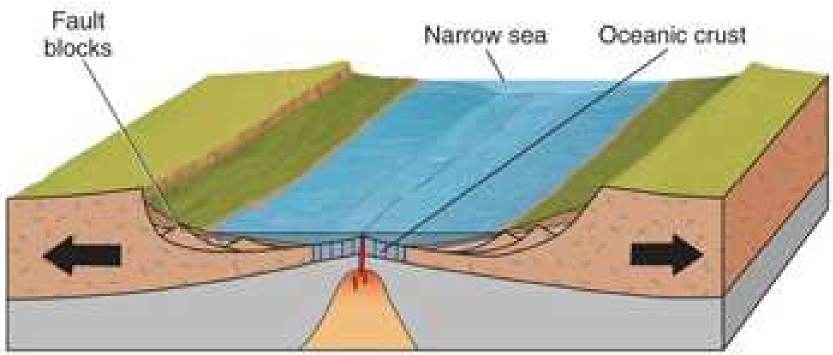
Tectonic Plate Boundaries

- *Divergent* boundaries
  - Plates move apart
  - Magma rises, cools and forms new lithosphere
  - Typically expressed as ***mid-oceanic ridges***
- *Transform* boundaries
  - Plates slide past one another
  - Fault zones, earthquakes mark boundary
  - San Andreas fault in California
- *Convergent* boundaries
  - Plates move toward each other
  - Mountain belts and volcanoes common
  - Oceanic plates may sink into mantle along a *subduction zone*, typically marked by a deep ocean trench

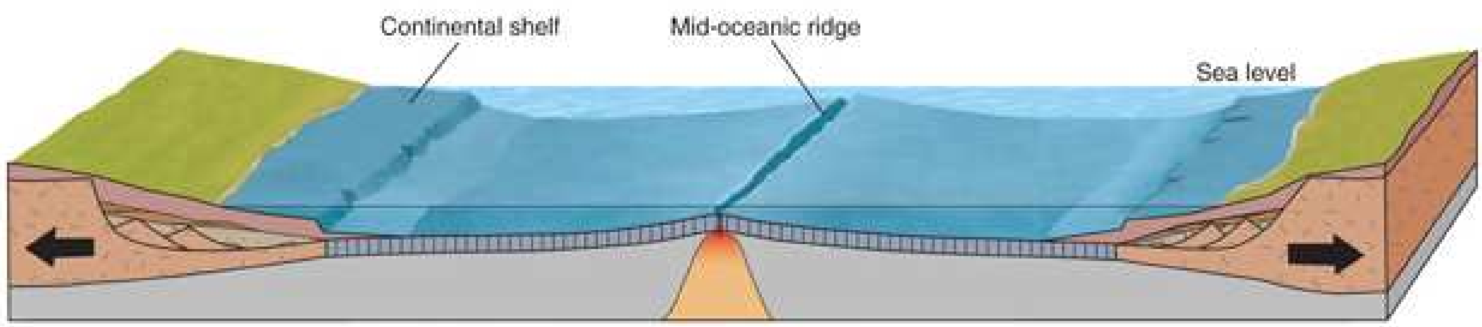




A–Continent undergoes extension. The crust is thinned and a rift valley forms.



B–Continent tears in two. Continent edges are faulted and uplifted. Basalt eruptions form oceanic crust.



C–Continental sediments blanket the subsiding margins to form continental shelves. The ocean widens and a mid-oceanic ridge develops, as in the Atlantic Ocean.

Divergent Boundaries

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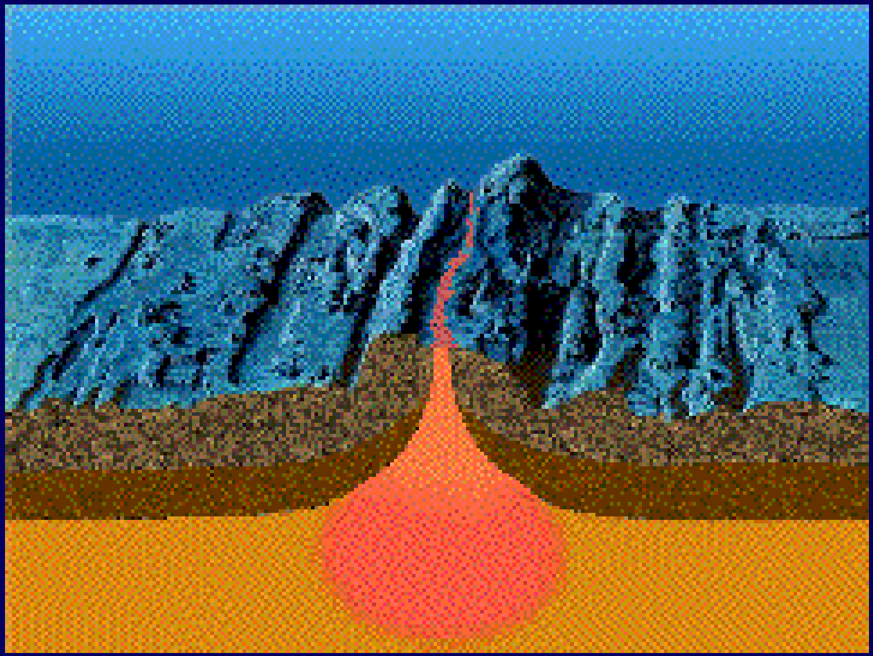
Divergent Boundaries



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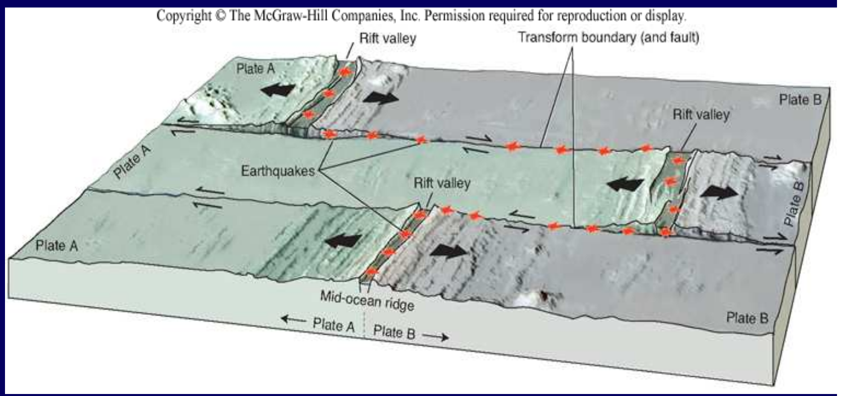

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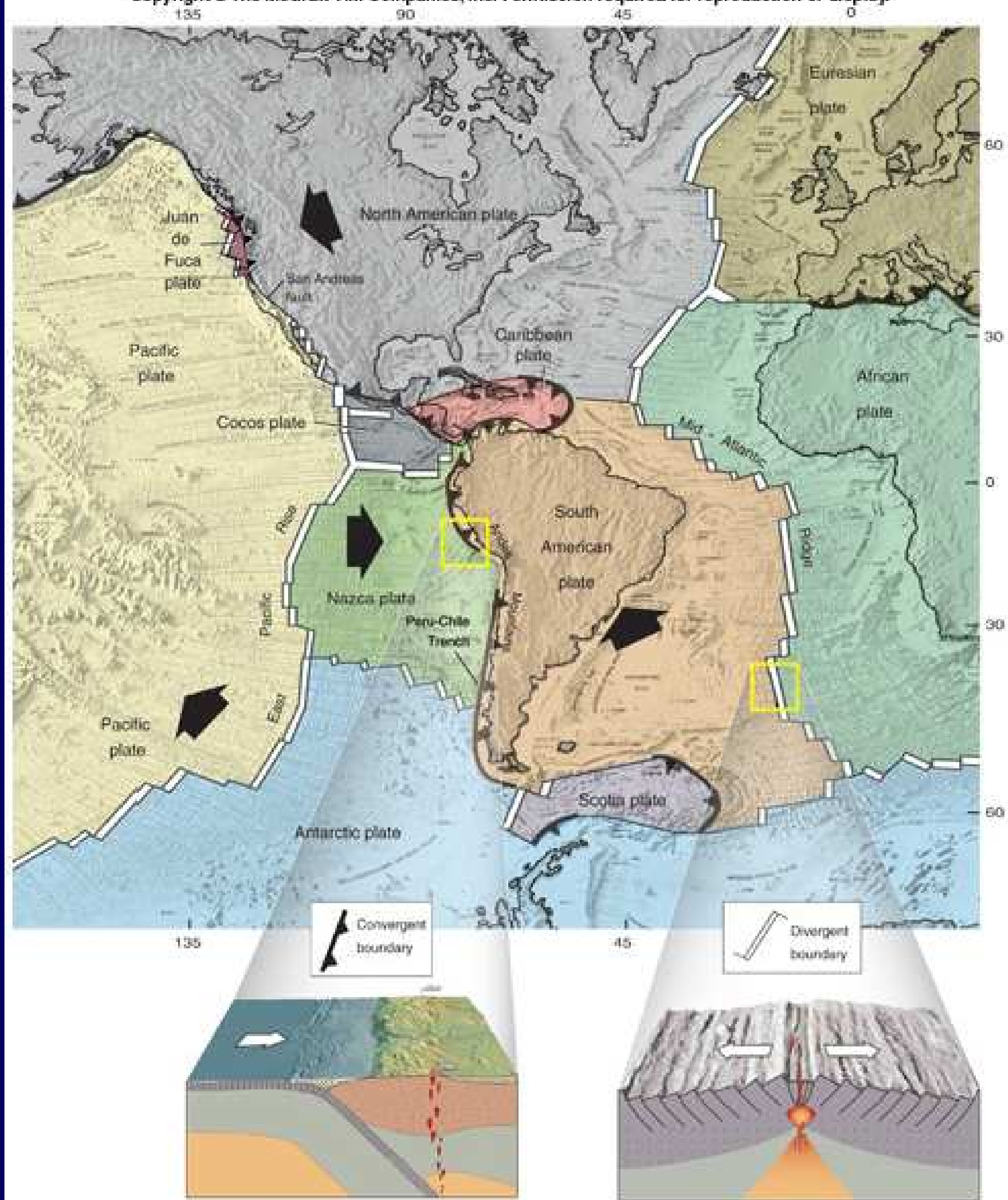

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Tectonic Plate Boundaries

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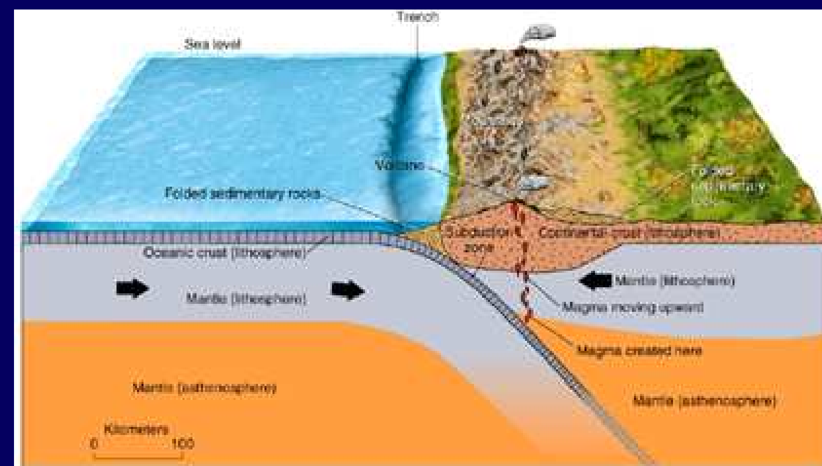

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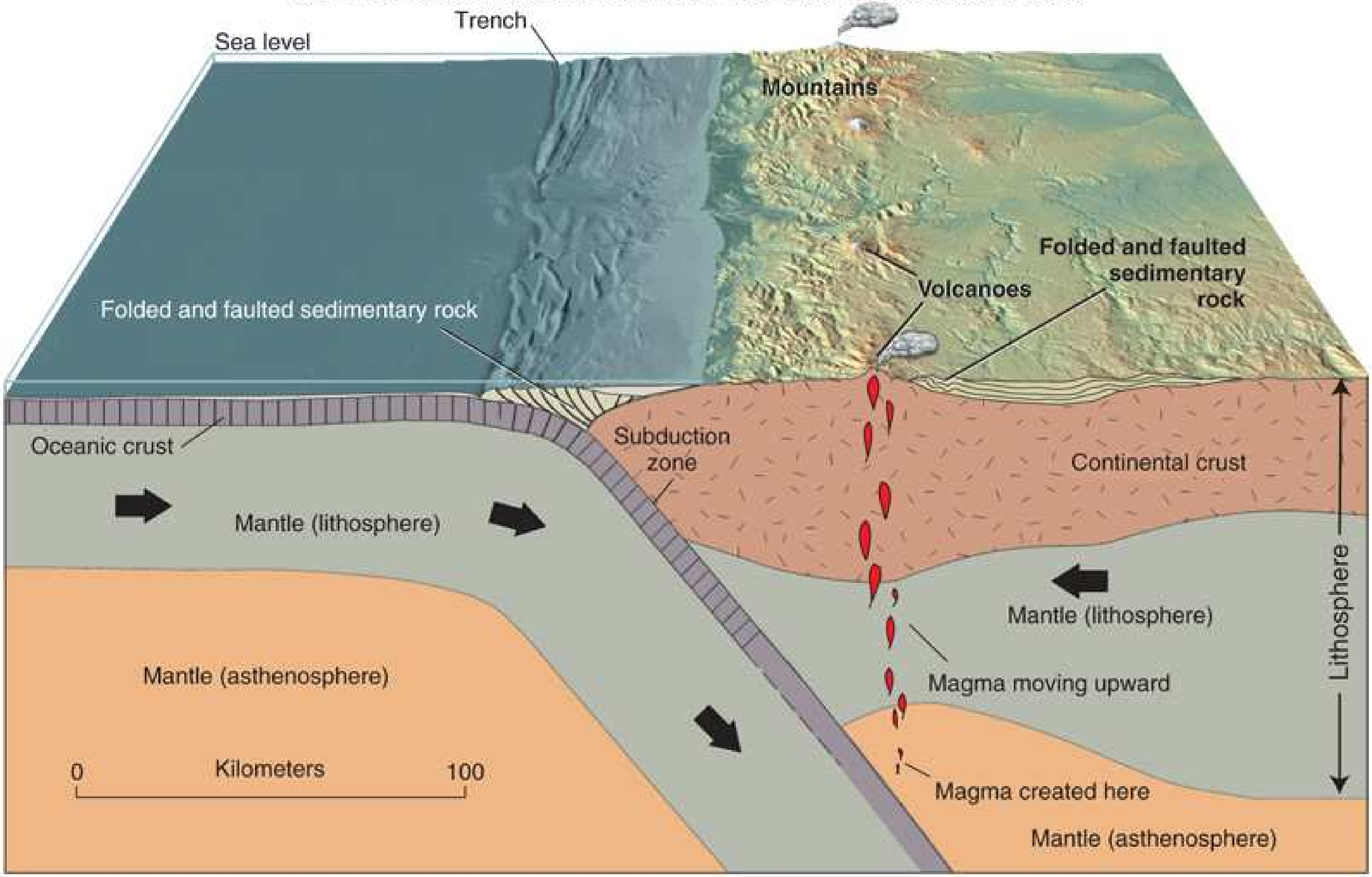
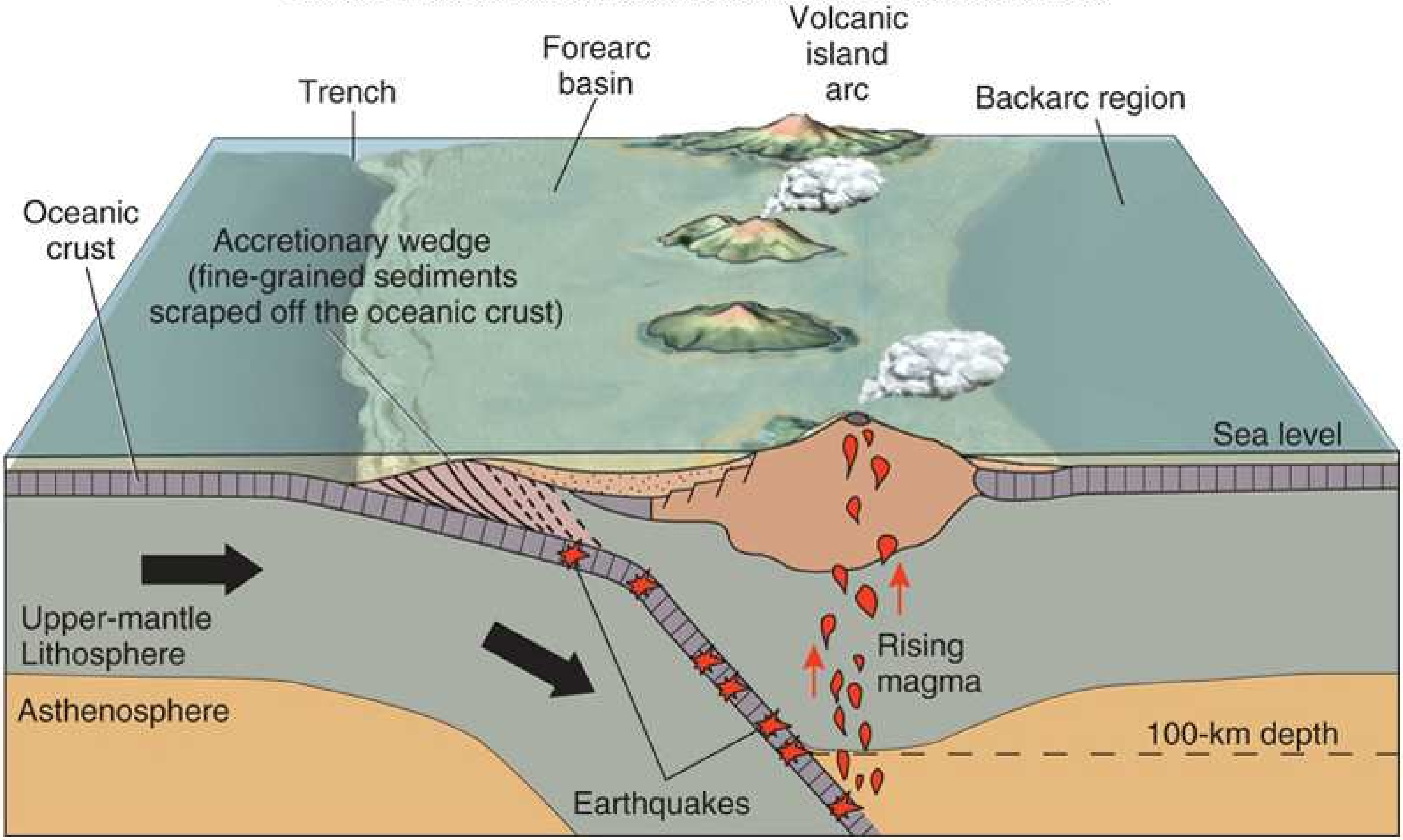
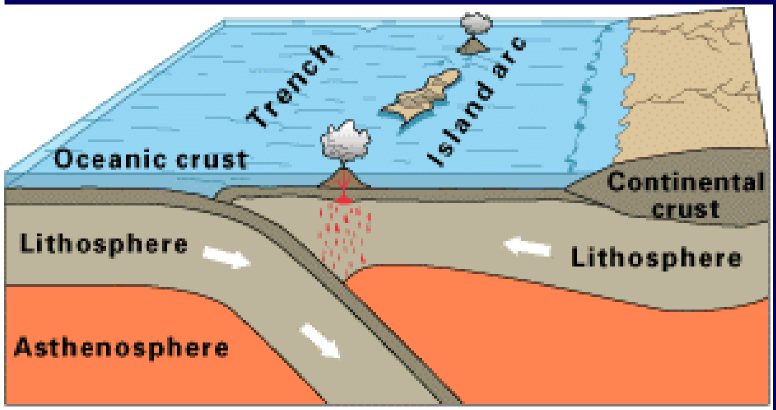

Trench
Sea level
Mountains
Folded and faulted sedimentary rock
Volcanoes
Folded and faulted sedimentary rock
Oceanic crust
Subduction zone
Continental crust
Mantle (lithosphere)
Mantle (lithosphere)
Lithosphere
Magma moving upward
Mantle (asthenosphere)
0
Kilometers
100
Magma created here
Mantle (asthenosphere)

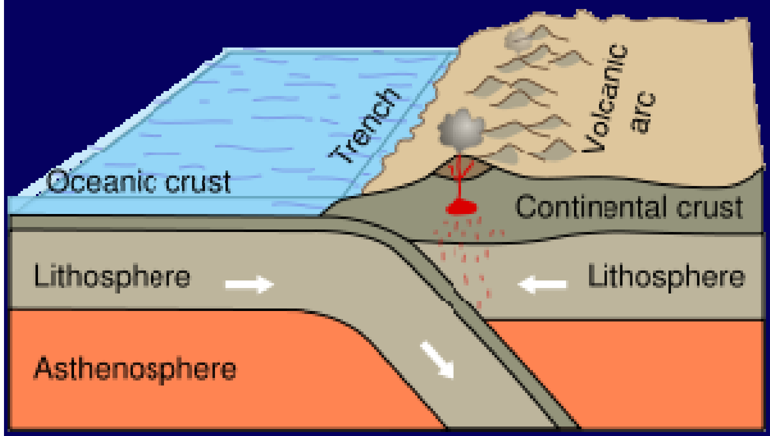

Volcanic island arc
Forearc basin
Trench
Backarc region
Oceanic crust
Accretionary wedge (fine-grained sediments scraped off the oceanic crust)
Sea level
Upper-mantle Lithosphere
Asthenosphere
Rising magma
100-km depth
Earthquakes



Oceanic-oceanic convergence

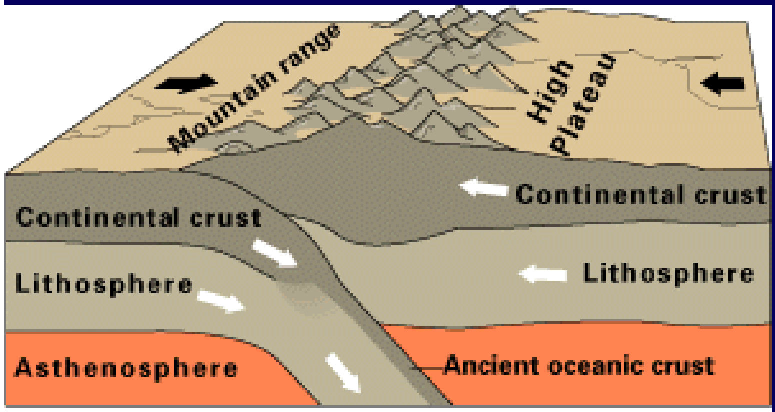
Oceanic-Oceanic Convergence:

Less dense plate subsides, produces Volcanic Island Arcs



Oceanic-Continental Convergence:

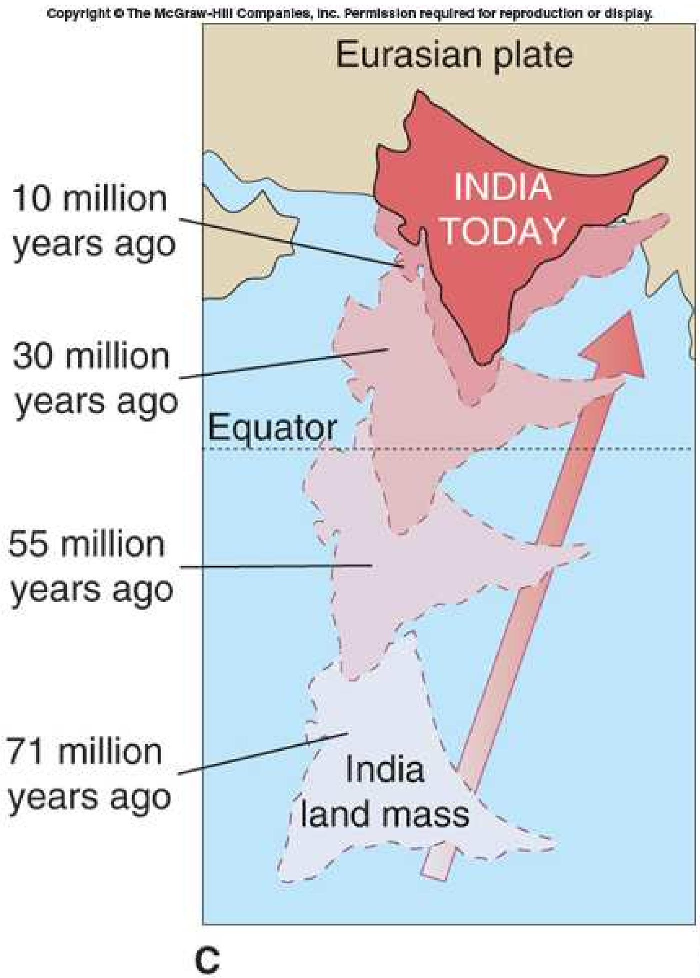
Oceanic plate subsides, produces Volcanic Mountain Ranges



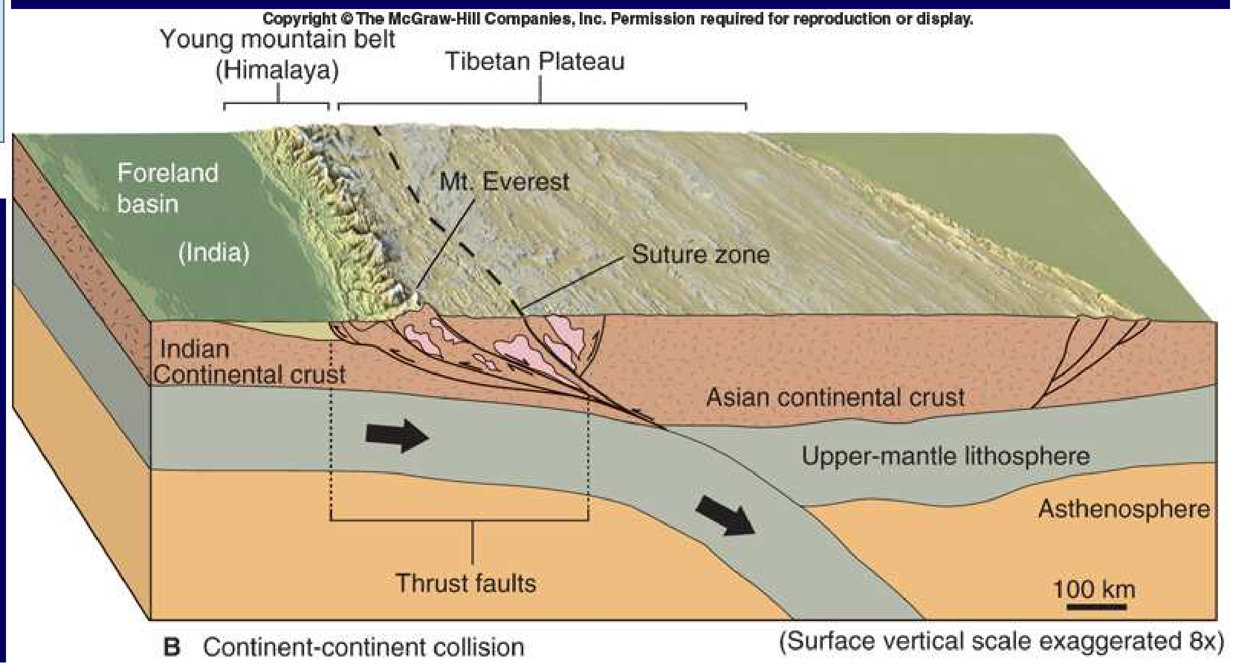
Continental-continental convergence

Continental-Continental Convergence :

Neither plate subsides, produces very high Mountain Ranges, e.g. Himalayas

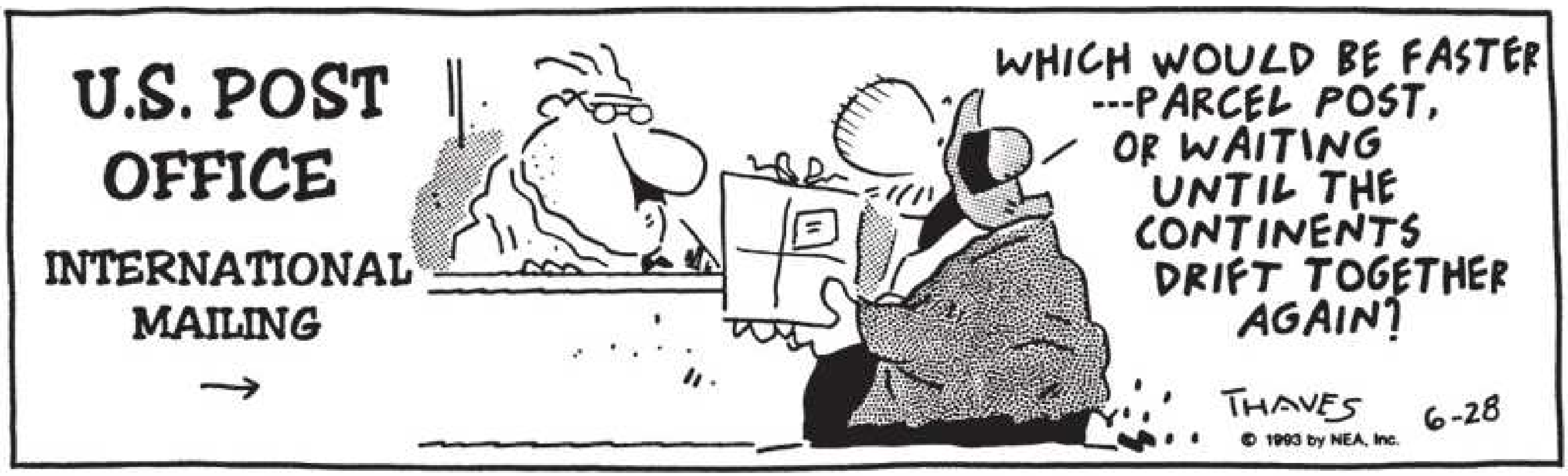


Formation of Himalaya and Mt. Everest



Divergence and Convergence Animations

FRANK & ERNEST® by Bob Thaves

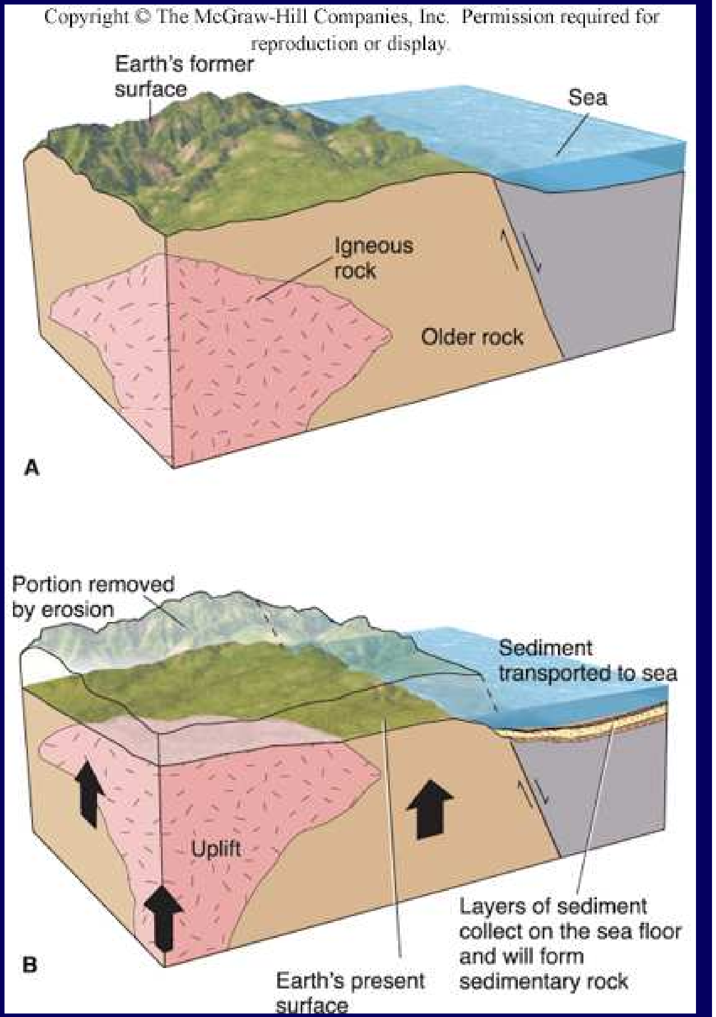


Surficial Processes:

How the Earth's External Heat Engine Works

Surficial Processes

- *Uplift*
  - Volcanic and/or tectonic forces build crust up above sea level
  - Removal of material by erosion allows ***isostatic uplift*** of underlying continental rocks
- *Weathering and Erosion*
  - Rainfall and glaciers flow down slopes
  - Moving water, ice and wind loosen and *erode* geologic materials, creating *sediment*
- *Deposition*
  - Loose sediment is deposited in low areas when transport agent (water, ice, wind) loses its carrying power
  - Earlier sediments get buried by later ones and harden into ***sedimentary rock***



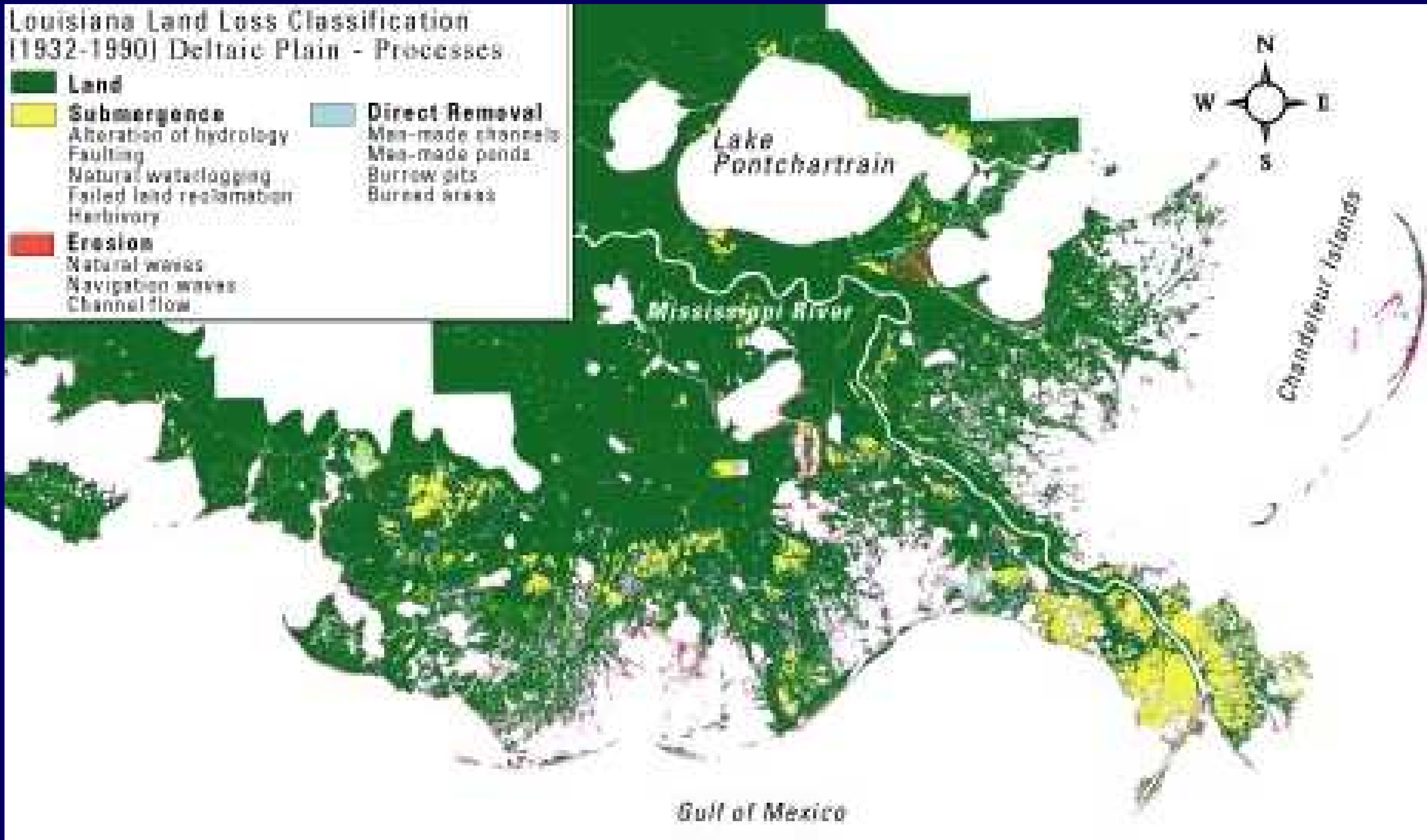
Isostasy

- Refers to the state of gravitational **equilibrium** between the lithosphere and asthenosphere such that the tectonic plates "float" at an elevation which depends on their thickness and density

- Thicker, denser portions of the crust sink, resulting in other thinner, less dense portions to rise

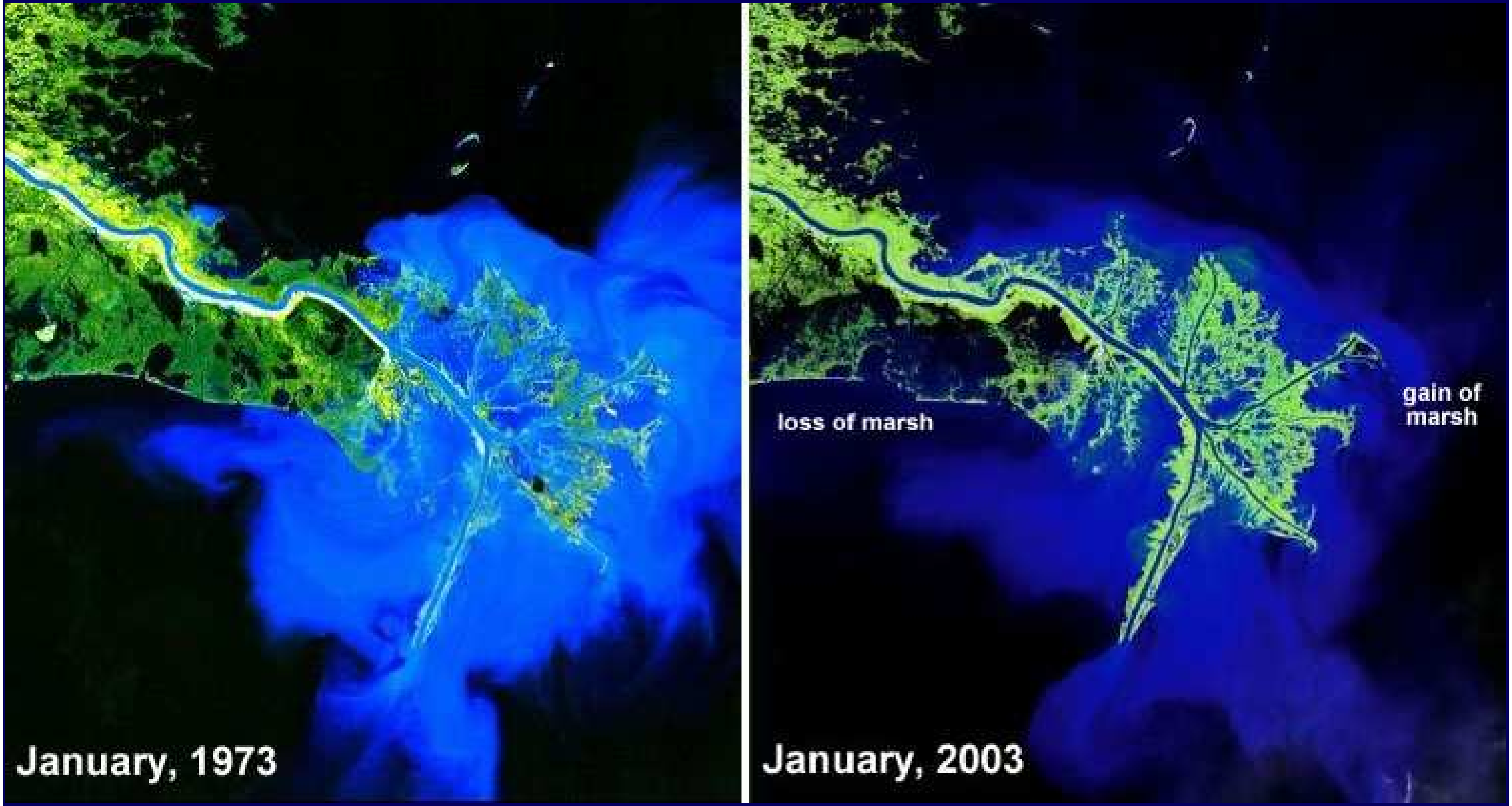
- E.G. Southern Louisiana

Subsidence



Louisiana Land Loss Classification
(1932-1990) Deltaic Plain - Processes
Land
Submergence
Alteration of hydrology
Faulting
Natural waterlogging
Failed land reclamation
Herbivory
Erosion
Natural waves
Navigation waves
Channel flow
Direct Removal
Man-made channels
Man-made ponds
Burrow pits
Burned areas
Lake Pontchartrain
Mississippi River
Chandeleur Islands
N
W
E
S
Gulf of Mexico

Result of Subsidence



Satellite images of the Mississippi delta showing extensive areas that have lost marshland as a result of subsidence between 1973 and 2003. The area that gained marshland during this time interval was receiving active sedimentation. **USGS Image.**

Next - Chapter 2: Earth's Interior and Geophysical Properties