Physical Geography

GEOGRAPHY 1710

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Chapter 11

The Dynamic Planet

The Dynamic Planet

- The Pace of Change
- Earth's Structure and Internal Energy
- The Geologic Cycle
- Plate Tectonics

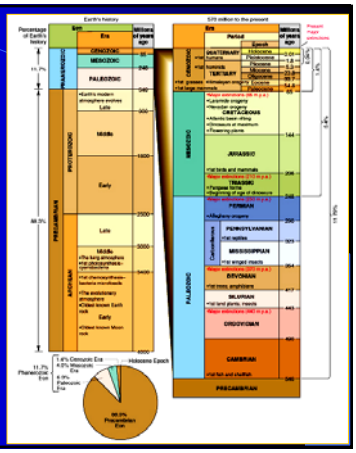
The Pace of Change

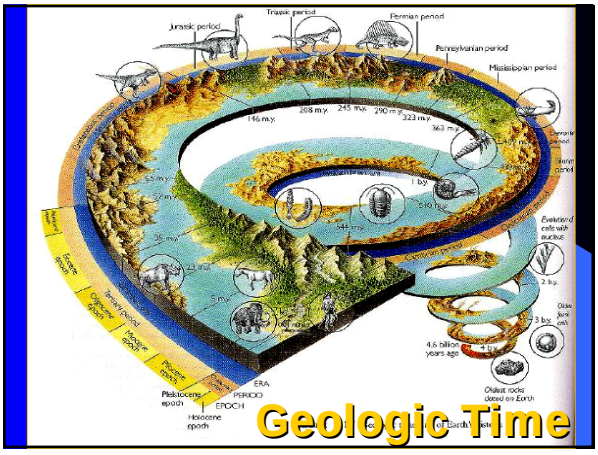
*Geologic time scale *Uniformitarianism

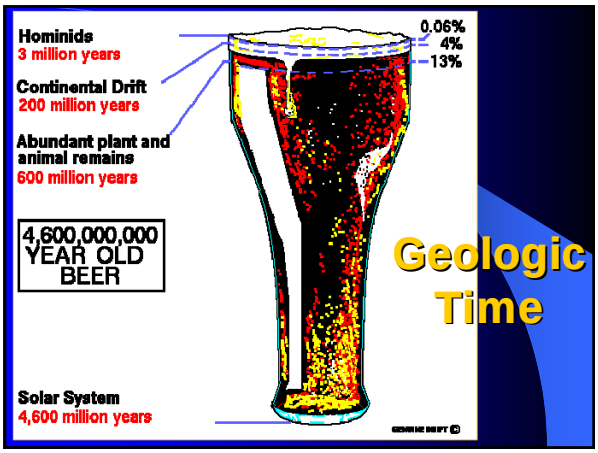
Geologic Time Scale

The perspective of geologic time requires a shift in our usual way of thinking.

The geologic time scale is the result of the collaboration of many earth scientists working together to construct a chronology of events on Earth.





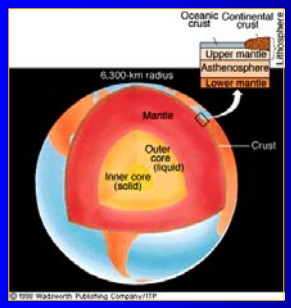


Lyell's uniformitarianism

("the present is the key to the past")

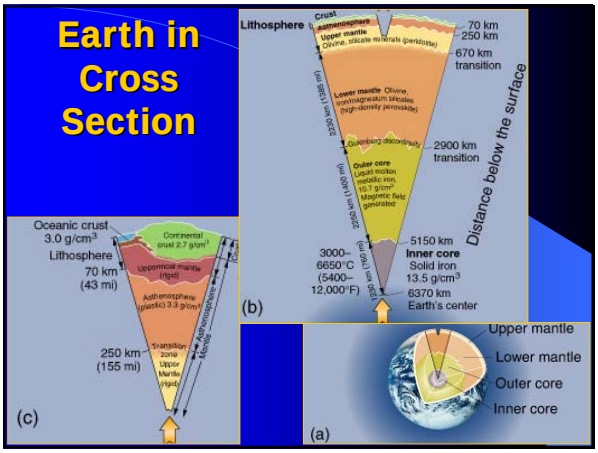
- Uniformity of law: the laws of science have not changed over time
- Uniformity of process: the natural processes going on on Earth today have always operated
- Uniformity of rate: the processes affecting the Earth have always operated at the same gradual rates and the same intensities
- Uniformity of state: the Earth has not changed overall

Earth's Structure and Internal Energy



- Earth's Core
- Earth's Mantle
- Earth's Lithosphere and Crust

Earth in Cross Section

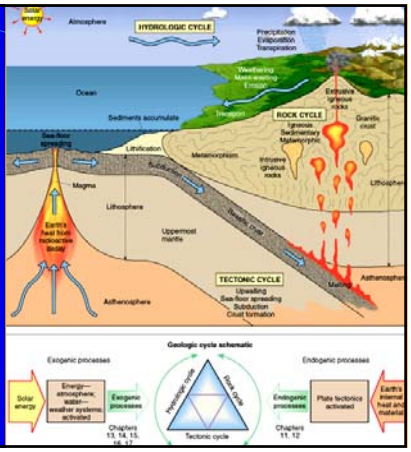


Core to Crust

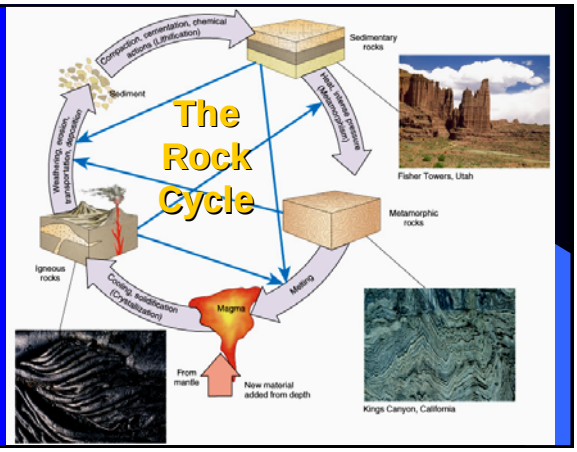
The Geologic Cycle

- Rock Cycle
- Minerals and Rocks
- Igneous Processes
- Sedimentary Processes
- Metamorphic Processes

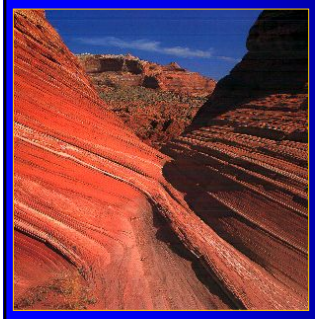
The Geologic Cycle



The Rock Cycle



The Rock Cycle



- Provides a way to examine the relationships between internal and external processes
- Relates Igneous, Metamorphic, and Sedimentary rocks to one another and to the processes which 'recycle' earth materials

The Rock Cycle

Igneous rocks
basalt, granite

Sedimentary rocks
limestone, conglomerate

Metamorphic rocks
gneiss, quartzite

Igneous Rock Types

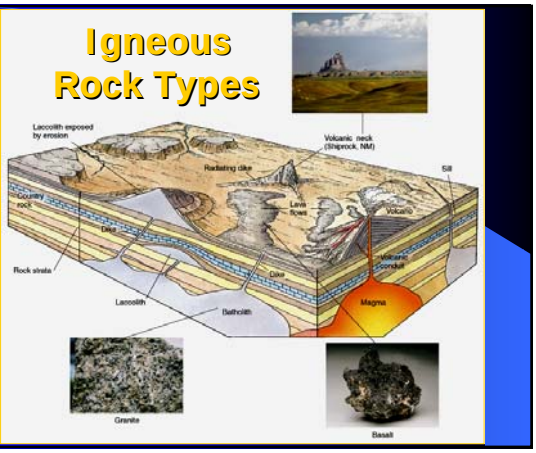
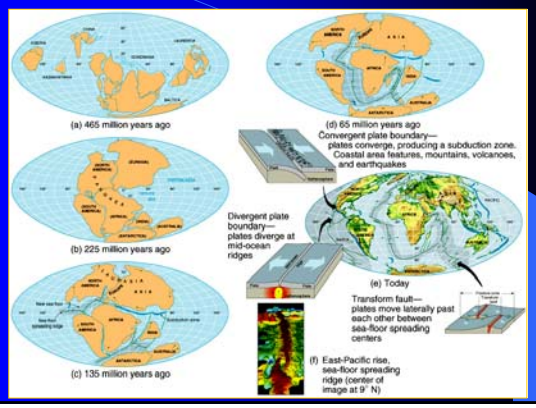


Plate Tectonics

- A Brief History
- Sea-Floor Spreading and Production of New Crust
- Subduction of the Crust
- The Formation and Breakup of Pangaea
- Plate Boundaries
- Earthquake and Volcanic Activity
- Hot Spots

Continents Adrift



What Were Some of the Early Ideas about Continental Drift?

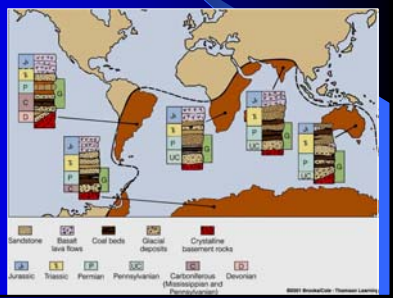
- 1915: Alfred Wegener wrote of a single supercontinent named Pangaea, meaning "all land"
- He portrayed the breakup of Pangaea and the movement of continents to their present position
- 1937: Alexander du Toit named Laurasia, the northern continental masses, and placed them so that extensive coal deposits on them were located at the equator

What Is the Evidence for Continental Drift?

- Continental Fit
  - In 1965 Sir Edward Bullard demonstrated that a better fit between the continents could be made if the continental shelf/slope boundary was used

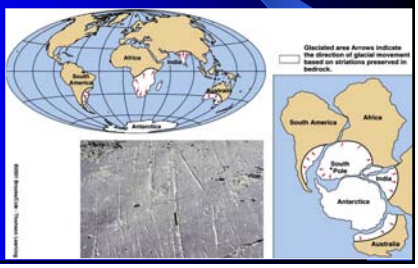
What Is the Evidence for Continental Drift?

- Similarity of Rock Sequences and Mountain Ranges
  - Marine, nonmarine, and glacial rock sequences are nearly identical for Gondwana continents
  - Trends of several major mountain ranges on separate continents match when the continents are repositioned



What Is the Evidence for Continental Drift?

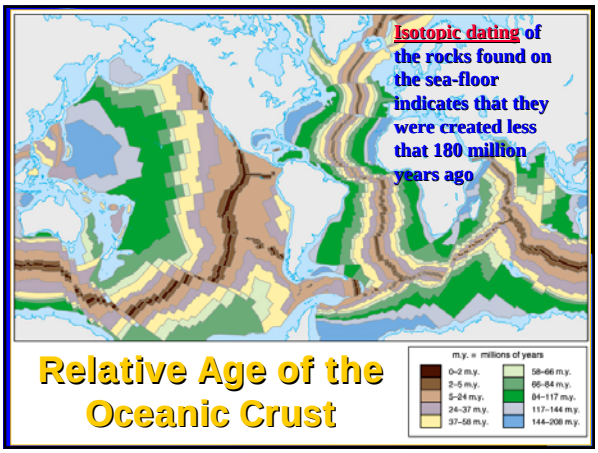
- Glacial Evidence
  - Striations and glacial deposits of the same age in the five southern continents suggest this reconstruction of Gondwana
- This reconstruction is consistent with fossil and climatologic evidence from Laurasia



The Evidence for Continental Drift

- Fossil Evidence
  - Glossopteris
  - Cynognathus
  - Mesosaurus
  - Lystrosaurus

- Paleomagnetism
  - remnant magnetism in ancient rocks recording the direction of Earth's magnetic poles at the time of the rock's formation
  - documents continental movement over time


Isotopic dating of the rocks found on the sea-floor indicates that they were created less that 180 million years ago
Relative Age of the Oceanic Crust
m.y. = millions of years
0–2 m.y.
2–5 m.y.
5–24 m.y.
24–37 m.y.
37–58 m.y.
58–66 m.y.
66–84 m.y.
84–117 m.y.
117–144 m.y.
144–208 m.y.

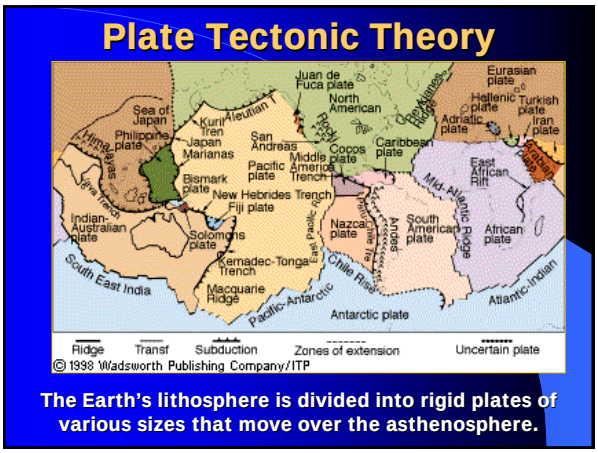


Plate Tectonic Theory
Juan de Fuca plate
Eurasian plate
North American
Hellenic plate
Turkish plate
Sea of Japan
Philippine plate
Kuril Trench
Aleutian Trench
Japan
Marianas
San Andreas
Cocos plate
Caribbean plate
Adriatic plate
Iran plate
Pacific plate
Middle America Trench
East African Rift
Bismark plate
New Hebrides Trench
Fiji plate
Mid-Atlantic Ridge
Indian-Australian plate
Nazca plate
South American plate
African plate
Solomons plate
Kermadec-Tonga Trench
East Pacific Rise
Chile Rise
South East India
Macquarie Ridge
Pacific-Antarctic
Antarctic plate
Atlantic-Indian
Ridge
Transf
Subduction
Zones of extension
Uncertain plate
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The Earth's lithosphere is divided into rigid plates of various sizes that move over the asthenosphere.

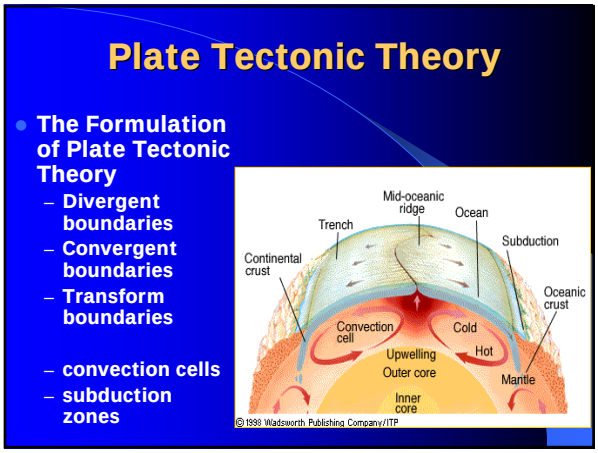
Plate Tectonic Theory
The Formulation of Plate Tectonic Theory
Divergent boundaries
Convergent boundaries
Transform boundaries
convection cells
subduction zones
Mid-oceanic ridge
Ocean
Trench
Subduction
Continental crust
Oceanic crust
Convection cell
Cold
Upwelling
Hot
Outer core
Mantle
Inner core
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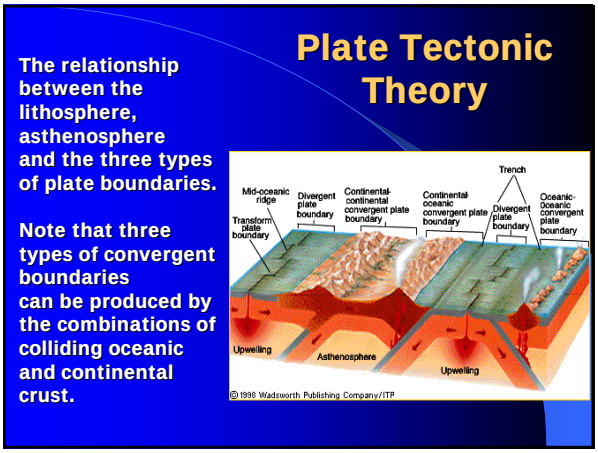
Plate Tectonic Theory
The relationship between the lithosphere, asthenosphere and the three types of plate boundaries.
Note that three types of convergent boundaries can be produced by the combinations of colliding oceanic and continental crust.
Trench
Mid-oceanic ridge
Divergent plate boundary
Continental-continental convergent plate boundary
Continental oceanic convergent plate boundary
Divergent plate boundary
Oceanic-Oceanic convergent plate boundary
Transform plate boundary
Upwelling
Asthenosphere
Upwelling
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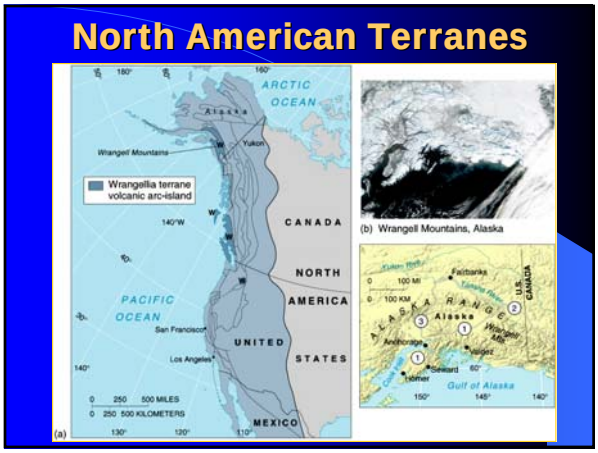
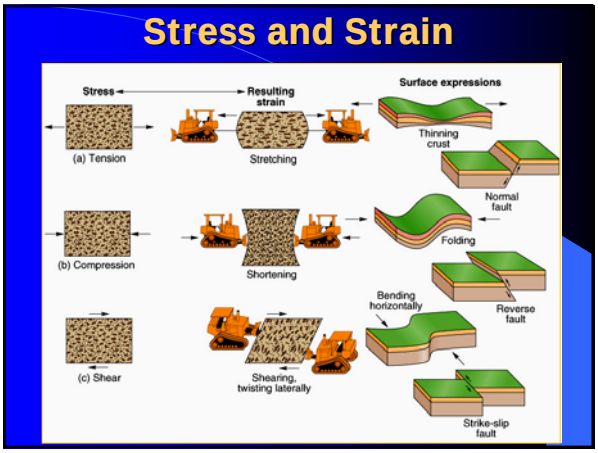
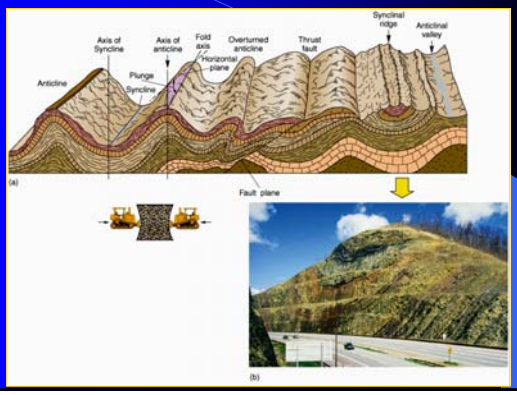
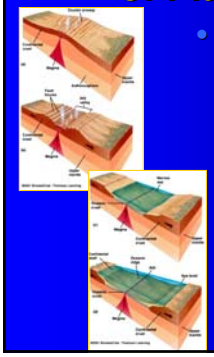

North American Terranes
ARCTIC OCEAN
Alaska
Wrangell Mountains
Yukon
Wrangellia terrane volcanic arc-island
CANADA
NORTH AMERICA
PACIFIC OCEAN
San Francisco
UNITED STATES
Los Angeles
MEXICO
0 250 500 MILES
0 250 500 KILOMETERS
(a)
(b) Wrangell Mountains, Alaska
Fairbanks
Anchorage
Seward
Valdez
Gulf of Alaska
U.S.
CANADA


Stress and Strain
Stress
Resulting strain
Surface expressions
(a) Tension
Stretching
Thinning crust
Normal fault
(b) Compression
Shortening
Folding
Reverse fault
Bending horizontally
(c) Shear
Shearing, twisting laterally
Strike-slip fault

Folding



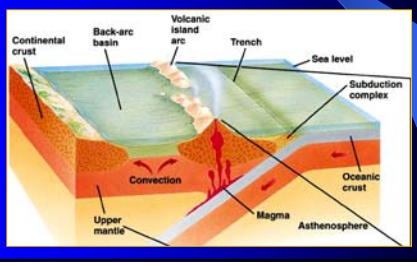
What Are the Three Types of Plate Boundaries?



- Divergent
  - Spreading ridges occur where plates are separating
  - may occur under oceanic or continental crust
  - rift valleys may lengthen and deepen, fill with sea water, basalts, and sediment to become a new sea

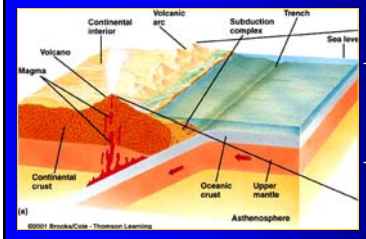
Convergent Boundaries

- Oceanic-oceanic
  - Subducting plate bends downward forming an oceanic trench
  - Volcanic island arc forms on the overlying plate
  - Back-arc basin fills with volcanoclastic sediment



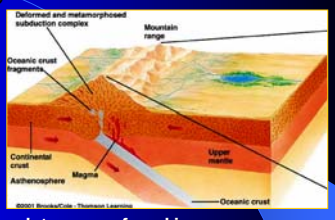
Convergent Boundaries

- Oceanic-continental
  - The denser oceanic plate is subducted under the continental plate
  - A subduction complex forms on the continent side of the trench
  - Partial melting of the descending oceanic plate forms an andesitic volcano mountain range

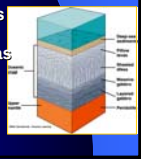


Convergent Boundaries

- Continental-continental
  - Low density continental crust is not subducted, but may partially underlie the other continental plate
  - Mountain ranges are formed in the interior of a new and larger continent

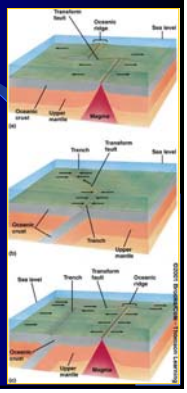


All rock types are found in these ranges, including slices of oceanic crust - ophiolites
Seismically active - Himalayas are the world's highest and youngest mountains

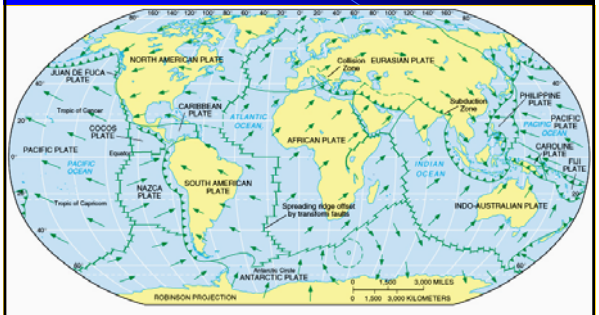


Transform Boundaries

- Transform faults
  - mark fractures in the crust where plates slide laterally past each other
  - change one type of motion to another
- The San Andreas fault separates the Pacific plate from the North American plate



Earth's Major Plates



Isostacy

"Wegener also noted that the continents move up and down to maintain equilibrium in a process called isostasy."