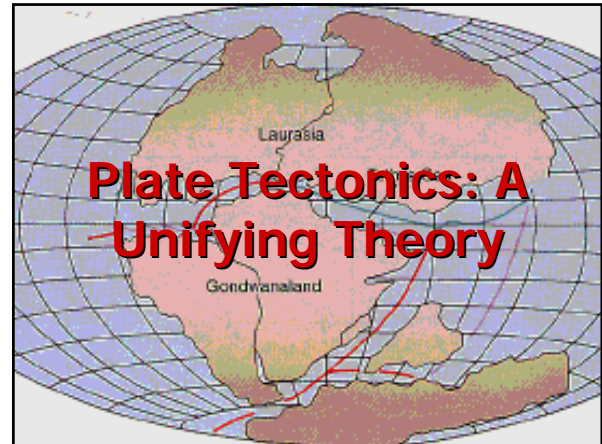


# Essentials of Geology

David Sallee

Chapter 15



## Plate Tectonics: A Unifying Theory

### Introduction

- Plate Tectonics is the unifying theory of geology
- Considerable geologic, paleontologic, and climatologic evidence is used to support the theory
- Three types of plate boundaries are recognized
- Interior processes are involved in plate movement



Alfred Wegener (1880-1930)

### What Were Some of the Early Ideas about Continental Drift?

- Early maps of South America and Africa led people to speculate that the continents may have been joined together and split
- Similarities exist between plant fossils on the southern continents. Glossopteris is the most conspicuous example of a unique flora in India, South Africa, Australia
- Similar glacial evidence also exists on these southern continents
- The supercontinent was named Gondwana



### 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

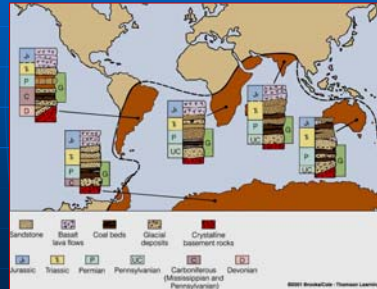


## What Is the Evidence for Continental Drift?

### 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

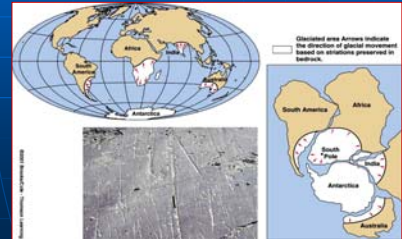


## What Is the Evidence for Continental Drift?

### 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

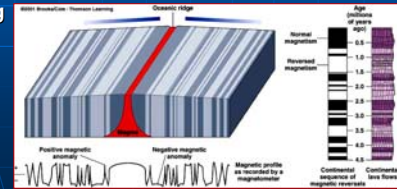
### Paleomagnetism

- 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

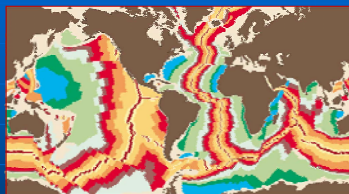


## Relationship between Magnetic Reversals and Seafloor Spreading

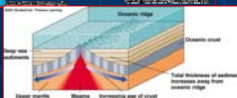
- Newly formed seafloor basalts record Earth's magnetic field at the time of crystallization
- Patterns of magnetic reversal correlate on either side of ridges
- Ocean basins are relatively young features



## Deep-Sea Drilling and the Confirmation of Seafloor Spreading



- Oceanic crust is youngest at the ridges and becomes progressively older with increasing distance from them
- Seafloor sediments are absent at the ridges and thicken with distance from them

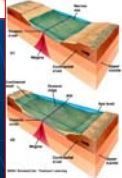
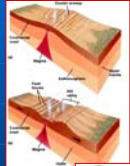


## Plate Tectonic Theory

- Plates of rigid lithosphere (oceanic and continental) move from the energy of heat transfer below
- Their interactions define divergent, convergent, and transform boundaries and control many surface processes including organic evolution



## What Are the Three Types of Plate Boundaries?

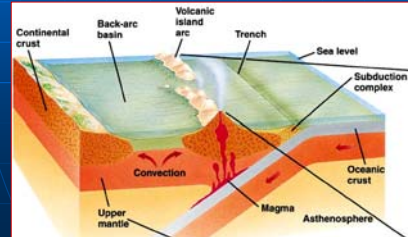


- Divergent**
  - Spreading ridges occur where plates are separating
  - may occur under oceanic or continental crust
  - rift valleys may lengthen and deepen, fill with sea water, basalts, and sediment to become a new sea



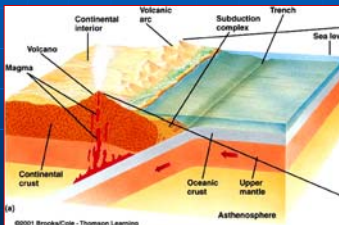
## Convergent Boundaries

- 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



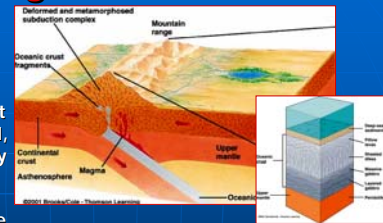
## Convergent Boundaries

- 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



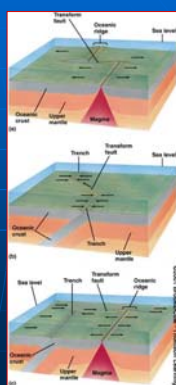
## Convergent Boundaries

- 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



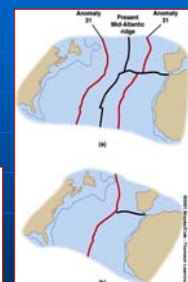
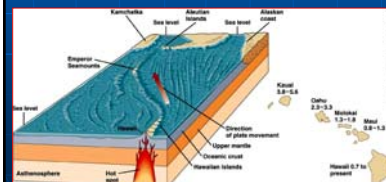
## Transform Boundaries

- 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**



## Determining Plate Motion

- Absolute dates of magnetic anomalies and distance traveled from ridge = rate
- Hot spots and associated features are used as fixed reference points to determine absolute motion



## Determining Plate Motion

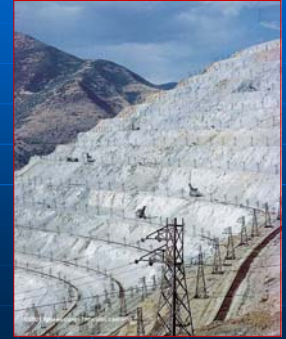
### Hot Spots

Hawaiian Islands  
Galapagos Islands  
Yellowstone



## Plate Tectonics and the Distribution of Natural Resources

- Oil in the Persian Gulf
- Metallic minerals
  - Gold, copper lead, silver, tin, zinc



## Plate Tectonics, Evolution, and the World's Biota

- Paleontologic evidence clearly shows the influence of plate movement on the distribution of organisms
- Climate and geographic barriers control the distribution of plants and animals - provinces
- Provinces don't share many organisms in common, so a dynamic crust creates new provinces and opportunity for new organisms
- Changes in wind and ocean currents, water clarity, temperature, topography, and geologic setting profoundly affect the distribution and evolution of organisms