DANCE OF THE CONTINENTS

An Introduction to Plate Tectonics

Preconceptions

Scrat's Continental Crack-Up

youtube.com/watch?v=q_IYQdKSwU8&feature=youtu.be
What did they get wrong?

What global mechanisms control geology?
Thinking about continents...

- **1596**
  - Cartographer Abraham Ortelius
  - Questioned idea that continents have always been where they are

- **1620**
  - English scientist Francis Bacon
  - Noticed the puzzle piece nature of Africa and South America

Continental Drift Theory

- **1910**
  - American geologist Frank Taylor
  - Suggested mountains are due to movement of continents

- **1912**
  - German meteorologist Alfred Wegener
  - Continental drift theory and the supercontinent Pangea
    - Distribution of fossils
    - Resemblance of geological structures
    - Distribution of ancient glacial deposits found near equator
Magnetic Proof

- Proof of continental drift
- 1950s
- Earth has a magnetic field, resembling a dipole magnet
- Iron-bearing minerals cooling in the Earth preserve the inclination of this magnetic field

- Inclination is dependant on latitude of mineral at time of cooling
- Using rocks of same age on different continents, we can place the continents in their original location
Magnetic Proof

- Inclination is dependant on latitude of mineral at time of cooling

But how do the continents move? By what mechanism?

Mapping the Seafloor

- 1950s
- Laying of submarine telephone cables
- Detection of 65,000km long ridge in Atlantic Ocean
- Detection of deep continuous trenches encircling Pacific ocean
Mapping the Seafloor

- **1960s**
  - Sea floor drilling - ocean floor is primarily basalt with a thin sediment layer
  - Magnetometers measured magnetic polarity of ocean floor
    - Notice of stripes parallel to ridge
    - Magnetic reversals
    - Symmetrical across ridge
    - Conveyor belt like process

Age of the Seafloor

- Red-Yellow: 0-70 million years old
- Green-Blue: 70-180 million years old
Seafloor Spreading

- 1962
  - American geologist Harry Hess
  - Oceanic ridge lies above diverging upwelling currents of convection cells in the mantle
  - Currents spread laterally at base of lithosphere
  - Pulling apart lithosphere – intruded by mafic magma
  - Pushing older seafloor away from ridge

*BUT… oldest seafloor is only 180 million years old? Where did the older crust go?*

Oceanic Trenches of the Pacific

- Japan
  - Many recorded earthquakes
  - Active volcanoes
  - Deep oceanic trench

- Western coast of South America
  - Many recorded earthquakes
  - Active volcanoes
  - Deep oceanic trench
Oceanic Trenches of the Pacific

- Japan
  - Many recorded earthquakes
  - Active volcanoes
  - Deep oceanic trench

In-class exercise – Earthquake Evidence and Plate Boundaries

- Many recorded earthquakes
- Active volcanoes
- Deep oceanic trench

Japanese Earthquakes

- 1928
- Geophysicist Kiyoo Wadati
  - Maps the depth and location of epicenters of earthquakes
  - Discovered an inclined surface sloping 60° beneath the Japanese Island, and beginning at the base of the deep trench
Subduction

- Earthquakes result of downward movement of ocean floor on large scale reverse faults
- Older seafloor sinks into the mantle along these subduction zones

Transform Faults

- Early 1960s
- Canadian researcher Tuzo Wilson
- Large scale seismically active transform faults
- Truncating and offsetting ridges and subduction zones
Plate Boundaries

- Earth divided into rigid lithospheric plates
- Boundaries defined by transform faults, spreading ridges and subduction zones
- Plates are constantly moving relative to each other

In-class exercise – GPS Data and Plate Motion
Divergent Boundaries

Rifting
A. Upwelling heat from mantle
B. Doming of continental land
C. Rifting and extrusion of magma
D. Small ocean basin formed
E. Large ocean basin with a mid-ocean ridge

Convergent Boundaries

- Ocean-ocean convergence
  - Island Arcs
  - Ex: Japan
- Ocean-continent convergence
  - Continental Arc
  - Ex: Andes in S. America
- Continent-continent convergence
  - Mountain belts – orogens
  - Ex: Himalayas
Mountain Building - Orogenesis

https://www.youtube.com/watch?v=d9bKXY0OMxc

Plate Tectonics – A Summary

- Unifying theory that took centuries to develop
- Describes the mechanisms by which the geology we see today is created
  - Earth is divided into rigid lithospheric plates which are constantly moving relative to each other
  - Plate movement is driven by convection in the mantle
  - Plate boundaries are either convergent (subduction and mountain building) or divergent (rifting and mid-ocean ridges)