Plate Tectonics and Structural Environments

Outline
- Structure of the Earth
- Lithosphere vs. Asthenosphere
- Plate Tectonics
- Plate Driving Forces
- Plate Boundaries
  - Divergent
  - Convergent
  - Transform

Earth’s Internal Structure 1
- 6380 km in diameter (~3800 miles)
- Core (3470 km)
  - Metallic (Fe, Ni)
    - Inner core - solid (1/3)
    - Outer core - liquid (2/3)
- Mantle (~2900 km)
  - Dense solid rock
    - Rich in Mg and Fe
- Crust (0-80 km thick)
  - Less dense
    - Rich in Si and Al

What are the Plates?
- Lithosphere
  - Crust + Uppermost Mantle
  - Rigid (tectonic plates)
- Asthenosphere
  - Weak part of the upper Mantle
**Asthenosphere**
- Mechanical boundary layer
- Zone of weakness
- Zone of partial melting (2-4% melt)
- Its depth is controlled by Temperature (1300 deg C)
- Allows the plates to slide over it

**Lithosphere/Asthenosphere**

**Ocean Basins vs. Continents**
- Continental crust: Light (2650 kg/m³), Granite, High elevation, Not so strong, Can be very old, Lasts for ever, Complex, Moves passively
- Oceanic crust: Dense (2850 kg/m³), Basalt, Low elevation, Strong, Young, Gets recycled, Simple, Drives plate motions

**The plates: Distribution of Earthquakes**

**Seafloor Spreading**
- Divergent (plates move apart)
- Convergent (plates move together)
- Transform (plates move past each other)
Seafloor Spreading 1

- Mantle convects at about 1-10 cm/yr
- Rising convection at mid-ocean ridges
- Sinking at the trenches
- Oceanic basins are impermanent, continents are permanent
- The earth is a dynamic body, its surface always changing.

The ocean floor is a tape recorder

Subduction

- Old ocean crust sinks into the mantle at the trenches
- Earthquakes show us where the slabs are
- Volcanoes form at subduction zones
**Subduction Zone**

**What causes the Plates to move?**

<table>
<thead>
<tr>
<th>Driving Force</th>
<th>Resisting Forces</th>
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<tbody>
<tr>
<td>Slab Pull (90%)</td>
<td>Basal Drag</td>
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<tr>
<td>Ridge Push (10%)</td>
<td>Mantle resistance</td>
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<tr>
<td></td>
<td>Continental resistance</td>
</tr>
<tr>
<td></td>
<td>Transform resistance</td>
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</tbody>
</table>

**Plate Motions**

**Motion with respect to what?**

$$v = ri \sin \Theta$$

**Plate Boundaries**

- Divergent boundary
- Transform boundary
- Convergent boundary

**Plate Tectonics and Structural Environments**

- **Plate Boundaries**
  - Divergent
  - Convergent
  - Transform
- **Structural Environments**
  - Extensional
  - Compressional
  - Strike-slip
  - Passive
Divergent Boundaries

Divergent Boundaries = Extensional Structural Environment

- State of Stress - extensional
- Processes - Thinning and stretching of the crust
- Types of Structures - rifts, normal faults
- Examples - mid-ocean rifts, Basin and Range, East Africa Rift

Normal Faults

Normal Faults

Basin and Range Province
Convergent Boundaries = Compressional Structural Environment

- State of Stress - compression
- Processes - Thickening and shortening of the crust
- Types of Structures - Fold and thrust belts, big mountains
- Examples - Andes, Himalayas, parts of the Rocky Mts.

Reverse and Thrust Faults

Folds due to horizontal shortening

The Appalachians

Canadian Rockies
Continental Collision

Collisional Boundary

The Himalayas

Mount Everest

Transform Boundaries=
Strike-slip Structural Environment

- State of Stress- horizontal shear
- Processes- shearing
- Types of Structures- transform faults, major strike-slip faults, (also normal and thrust)
- Examples- San Andreas fault, Alpine fault (NZ), Anatolian fault (Turkey)
• Transform Boundary
• The most famous fault

San Francisco Bay
San Andreas Fault

Oceanic Transform Fault
What type of plate boundary is there along the US East coast?

Passive Margin