Plate Tectonics
Chapter 2

Interactions at plate boundaries depend on the direction of relative plate motion and the type of crust.

Which kind of plate boundary is associated with Earthquake activity?

A. Divergent Boundary
B. Convergent Boundary
C. Transform-fault Boundary
D. All of the above

Interactions at plate boundaries depend on the direction of relative plate motion and the type of crust.

At which kind of plate boundary is new oceanic lithosphere formed?

A. Oceanic transform boundary
B. Oceanic divergent boundary
C. Ocean-ocean convergent boundary
D. Ocean-continent convergent boundary

Plate Tectonics: Learning Goals

- Scientific Method
  - Development of Plate Tectonics Theory
- Lithosphere vs Asthenosphere
- Crust vs Mantle
- Plates contain continent and ocean
- Plate boundaries (where the action is)
  - Convergent Boundaries
  - Divergent Boundaries
  - Transform Boundaries
Divergent, Convergent and Transform plate boundaries

Crust and Mantle vs Lithosphere and Asthenosphere

Plates are lithosphere: Both continent and ocean crust

Scientific Method

1. Observation (fact)
   - This is a repeatable measurement or experiment

2. Hypothesis
   - One or more possible explanations to link observations

3. Testing
   - Further experiment or observation to test hypothesis
   - Non-testable hypotheses also rejected

4. Theory
   - A grand or unifying hypothesis that has survived tests
   - Relativity, Evolution, Plate tectonics

1. Observation:
   Early Evidence (Wegener)
   - The geometric fit of the continents.
   - The similarity in rock age groups between adjoining regions.
   - The similarity in Paleozoic fossils between adjoining areas.
   - The distribution of Paleozoic glaciation in S.America, S.Africa, Australia, and India.

The geometric fit of the continents.
**Similarity of Paleozoic Fossils in adjoining regions.**

**Early Objections**
- Mantle is solid
  - (Transmits Shear waves).
- How can continents move and remain intact?
- What is the driving force?

**1960s: Compelling New Evidence: Magnetic Anomalies**
- Magnetic minerals such as magnetite ($\text{Fe}_3\text{O}_4$) record Earth's magnetic field.
- They also perturb the field by a small amount.
- Perturbations are called magnetic anomalies.
- Anomalies can be mapped using magnetometers dragged behind aircraft or ships.

**Magnetic Anomalies**
- Anomalies were first solid evidence of sea-floor spreading.
- Here was a credible hypothesis that demanded testing.

**2. The Hypothesis:**
- The continents have moved (drifted) over geologic time so that North and South America have separated from Europe and Africa.
3. Test the Hypothesis

- The hypothesis makes several predictions that allow it to be tested by further observation.
  - Rocks in adjoining parts of Africa and South America should be similar in age and type.
  - Rocks on Atlantic floor should get younger toward the mid-ocean ridge.
  - New bathymetric measurements define the continental crust boundary. Do South America and Africa still fit together?
  - If crust is being created at mid-ocean ridges, it should also be consumed. Where is the crust consumed?
  - There needs to be a driving force.

Rocks in adjoining parts of Africa and South America were age-dated using new radioactive methods; they matched perfectly.

Rocks were dredged from the sea floor: they showed ages symmetrically increasing away from the ridge. There were no old rocks (>250MY).

- The fit of continents was revised using the edge of the continental slope rather than the coastline: the match was nearly perfect.

Rocks were dredged from the sea floor: They showed ages symmetrically increasing away from the ridge. There were no old rocks (>250MY).

3. Test the Hypothesis

4. Theory of Plate Tectonics

- There appear to be 13 major plates that cover the globe.
- The plates can contain oceanic, or continental crust or both.
- New oceanic crust is created at the mid-ocean ridge (divergent boundary).
- Old oceanic crust is consumed (subducted) at convergent plate boundaries.

Continental Margins: Passive and Active
Divergent, Convergent and Transform plate boundaries

Crust and Mantle vs Lithosphere and Asthenosphere

Interactions at plate boundaries depend on the direction of relative plate motion and the type of crust.

Divergent Boundaries
Oceanic Plate Separation

Key Figure 2.6 (pages 26-27)
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Divergent Boundaries
Oceanic Plate Separation
Volcanoes and earthquakes concentrate.

Mid-Atlantic Ridge

Divergent Boundaries
Continental Plate Separation

East African Rift Valley

Divergent Boundaries
Continental Plate Separation
Parallel valleys; volcanoes and earthquakes.

East African Rift Valley

Divergent Boundaries

- Mid-Atlantic Ridge
- East Pacific Rise
- Red Sea-East Africa rift

Iceland
**Convergent Boundaries**

**Ocean-Ocean Convergence**
- Mariana Islands
- Marianas Trench
- Deep-sea trench; volcanic island arc.

**Ocean-Continent Convergence**
- Andes Mountains
- Peru-Chile Trench
- A volcanic belt of mountains forms.
Convergent Boundaries

- **Ocean – Ocean**
  - Tonga trench
  - Marianas Trench
- **Ocean - Continent**
  - West coast South America
  - Japan Trench
  - Aleutians
- ** Continent – Continent**
  - Himalayas
  - Alps

Crust crumbles, creating high mountains and a wide plateau.

Divergent, Convergent and Transform plate boundaries

Transform-Fault Boundaries

Mid-Ocean Ridge Transform Fault

Spraying centers offset.

Transform-Fault Boundaries

Mid-Ocean Ridge Transform Fault
Transform-Fault Boundaries
Continental Transform Fault

As plates move past each other...
...creek beds are offset

The San Andreas fault

Offset continental crust.

San Francisco
Los Angeles

The San Andreas fault
The San Andreas fault
Looking SW from Joshua Tree

As plates move past each other...
Pacific Plate
N. American plate

Transform Boundaries

- San Andreas Fault
- Cuba
- North coast South America

Divergent, Convergent and Transform plate boundaries

There appear to be 13 major plates that cover the globe.

Theory of Plate Tectonics

- Continental crust resists subduction.
- Continent-continent convergent boundaries form major mountains.
- Ocean-ocean and ocean-continent convergent boundaries form subduction zones marked by deep ocean trenches and Benioff Zones (deep earthquake zones extending to 670km).
Assignment
Read Grotzinger Chapter 3
Earth Materials

Divergent Boundaries
• Mid-Atlantic Ridge
• East Pacific Rise
• Red Sea-East Africa rift

Transform Boundaries
• San Andreas Fault
• Cuba
• North coast South America

Convergent Boundaries
• Ocean – Ocean
  – Tonga trench
  – Marianas Trench
• Ocean - Continent
  – West coast South America
  – Japan Trench
  – Aleutians
• Continent – Continent
  – Himalayas
  – Alps