Focus on Earth Science

An Integrated Middle School Series
Plate Tectonics and Earth’s Structure

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Chapter Eight: Plate Tectonics

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8.1 Wegener’s Supercontinent

- Alfred Wegener was a German climatologist and arctic explorer who suggested the concept of continental drift.
- **Continental drift** is the idea that the continents move around on Earth’s surface.
8.1 Wegener’s Supercontinent

225 million years ago

- Wegener thought that the continents we know today had once been part of an earlier supercontinent.
- He called this great landmass Pangaea.
8.1 Wegener’s Supercontinent

- The surface of Earth is broken into many pieces like a giant jigsaw puzzle.
- **Plate tectonics** describes how these pieces move on Earth’s surface.
8.1 Evidence for continental drift

- Wegener’s belief was a *scientific hypothesis based on observations*.  
- Continental drift could not be accepted by all scientists because there was no evidence to explain how continents could move.
Evidence for Continental Drift
Map with Fossil Locations

Where animals lived on ancient continents

Where fossils are found today

Ancient continents
Modern continents

Range of animals

- Cynognathus
- Glossopteris
- Lystrosaurus
- Mesosaurus

Glacial limit

Cynognathus
Glossopteris
Lystrosaurus
Mesosaurus
The La Brea tar pits contain a large number of mammal remains including saber-toothed cats, mammoths, dire wolves, and short-faced bears. Scientists believe large animals or prey became trapped in the tar.
8.2 Undersea mountains discovered

- American geophysicist Harry Hess helped develop the theory of plate tectonics.
- While a Navy officer, Hess helped map the ocean floor.
8.2 Undersea mountains discovered

- Naval maps showed undersea mountain chains that formed a continuous chain down the centers of the ocean floors.
- Hess wondered if new ocean floor was created at these mid-ocean ridges.
Harry Hess’ Idea

As new sea floor is made at mid-ocean ridges, the continents are pushed away.

(The ocean is not shown)
8.2 Harry Hess’ idea

- Hess called his hypothesis **sea-floor spreading**.
- The key was the discovery that there are “magnetic patterns” in the rocks on either side of the mid-ocean ridges.
- Matching magnetic patterns and the age of rocks on either side of mid-ocean ridges provided strong evidence for sea-floor spreading.
Sea-Floor Spreading

- Mid-ocean ridge
- Matching magnetic patterns on either side of the ridge

Age (Millions of years)

Crust

Mantle

Magma
8.2 Moving pieces of lithospheric plates

- Scientists realized that large pieces of Earth’s surface moved about like rafts on a river.
- These “rafts” are pieces of lithosphere called **lithospheric plates**.
- Plate tectonics is the study of these lithospheric plates.
8.2 Moving pieces of lithospheric plates

- There are two kinds of lithospheric plates: **oceanic plates** and **continental plates**.
8.2 What drives lithospheric plates?

- Convection cells in Earth’s lower mantle drive the lithospheric plates on the surface.
- Heated lower mantle material rises toward Earth’s surface.
8.2 What drives lithospheric plates?

- Cooling makes the nearby material denser and it sinks deeper into the lower mantle.
- This sinking process is called **subduction**.
8.2 Hot spots and island chains

- A single hot rising plume, called a **mantle plume**, can cause a volcanic eruption in the plate above it.
- If the eruption is strong and lasts long enough, the volcanic eruption may form an island on the plate.
8.2 Hot spots and island chains

- After the island forms, the movement of the plate carries it away from the mantle plume.
- Scientists determine the direction and speed of plate movement by measuring these island chains.
Investigation 8A

Introduction to Metamorphic Rocks

• What is necessary for the formation of metamorphic rocks?
Imagine a single plate, moving in one direction on Earth’s surface.

One edge of the plate—the \textit{divergent boundary}—moves away from things.

The opposite edge—called the leading edge or \textit{convergent boundary} bumps into anything in the way.
8.3 Plate boundaries

- An edge of a lithospheric plate that slides by another plate is called a **transform fault boundary**.
Plate Boundaries

**Divergent**
Plates move apart

**Convergent**
Plates come together
One plate goes under another
Mountains form

**Transform**
Plates slide past each other
8.3 Divergent boundaries

- Divergent boundaries are found in the ocean as mid-ocean ridges.
- A divergent boundary is the line between two plates where they are moving apart.
- This type of boundary is found over the rising plume of a mantle convection cell.
8.3 Divergent boundaries

• Divergent boundaries can also be found on continents as **rift valleys**.

• When a rift valley forms on land, it may eventually split the landmass.
8.3 Convergent boundaries

- When oceanic plates collide, one subducts under the other.
- This forms a valley in the ocean floor called a trench.
Convergent Plate Boundary

- Trench
- Island arc
- Sediments
- Volcano
- Oceanic crust
- Oceanic lithosphere (younger plate)
- Oceanic lithosphere (older plate)
- Aesthenosphere
- Region of melting
- Water released from subducted crust

A spot here will move closer to the trench as the plate subducts.
8.3 Convergent boundaries

• What happens if an oceanic plate and a continental plate collide?
• Which plate would subduct?
• The oceanic plate must subduct under the continental plate.
• A continental plate is simply too buoyant to subduct under an oceanic plate.
Collision of Nazca and South American Plates

Andes Mountains, Peru

Photograph by George Ericksen, USGS

Nazca Plate
Oceanic plate basalt, denser, less buoyant, sinks under the continental plate

South American Plate
Continental plate, andesite and granite, less dense, more buoyant, floats above the oceanic plate
What happens if an oceanic plate with a continent on it subducts under a continental plate?
- The continents cannot be sucked into the trench because their granite rocks.
- The two continents collide!
8.3 Mountains and convergent boundaries

What happens when two continents collide?

- Mountain ranges are formed when continents collide.
Formation of the Himalayan Mountains

mya = Millions of years ago
8.3 Transform fault boundaries

- A good clue for locating transform faults is *offsetting*.
- When seen from above, the feature will appear to make a zig-zag.
Earth’s Largest Lithospheric Plates

- American Plate
- Pacific Plate
- African Plate
- Indo-Australian Plate
- Antarctic Plate
- Eurasian Plate
- Pacific Plate

The diagram illustrates the major tectonic plates of the Earth, showing their relative positions and movements.
Activity

Make a Plate Tectonics Book

• Your book will recount part of the plate tectonics story.

• Use the graphic on this page and others in Chapter 8 to help you outline your story.
8.4 Metamorphic Rocks

- **Metamorphism** means to change the form of something.
- A *metamorphic rock* is a rock formed from another kind of rock due to heat and pressure.
8.4 Metamorphic Rocks

- When magma comes in contact with another type of rock, the high heat may form metamorphic rock near the point of contact.
- This is called **contact metamorphism**.
8.4 Metamorphic Rocks

- Heat and pressure result when colliding continents form mountains at a convergent boundary.
- Mountains are where we find metamorphic rocks.
8.4 Metamorphic Rocks

- Limestone is a rock made of shells.
- At subduction zones, it is metamorphosed into marble under heat and pressure.
8.4 Metamorphic Rocks

- Italy lies near a convergent boundary.
- Italy is also the source of some of the world’s finest marble.
Investigation 8B
Formation of Metamorphic Rocks

• How do metamorphic rocks form?