

## Chapter 3, The Origin of Ocean Basins

### LEARNING OBJECTIVES

1. Understand the processes that are continuously changing Earth's surface as lithospheric plates move relative to one another.
2. Identify the role of oceanic ridges, transform faults and deep-sea trenches in defining the edges of lithospheric plates.
3. Understand the importance of asthenospheric thermal convection in plate tectonics and the resulting compression or tensional forces at the plate boundaries.
4. Explain the distribution of magnetic anomaly stripes, seismicity, and volcanism in terms of the concept of global plate tectonics.
5. Calculate spreading rates of ocean basins.

### CHAPTER OUTLINE

- A. **Ocean basin** is defined as that part of the sea floor deeper than 2000 m (6000 ft).

#### 3-1. Continental Drift

- B. Based upon the fit of continental outlines and fossil and geologic evidence, **Alfred Wegner** proposed that the continents are sections of a past super continent called **Pangea**, which broke apart and the fragments plowed through the oceanic crust to their present locations.
- His hypothesis, called **continental drift**, was rejected because oceanic crust is too dense and strong for continents to move through it.

### 3-2. Sea-Floor Spreading

- C. Sea floor spreading demonstrates that the sea floor moves apart at the oceanic ridges and that new oceanic crust is added to the edges.
1. Rift valleys along oceanic ridge crests indicate tension, are bounded by **normal faults**, and are floored by recently-erupted basaltic lava flows.
  2. Axis of the oceanic ridge is offset by **transform (strike-slip) faults**, which produce lateral displacement.
  3. Whereas oceanic ridges indicate tension, continental mountains indicate **compressional forces** are squeezing the land together.
- D. The **geomagnetic field** is the magnetic field of the Earth.
1. **Magnetometers** detect and measure Earth's magnetic field.
  2. Moving across the ocean floor perpendicularly to the oceanic ridges, magnetometers alternately record stronger (positive) and weaker (negative) magnetic fields (called **magnetic anomalies**) in response to the influence of the sea floor rocks.
  3. **Magnetic anomalies** and the rocks causing them form parallel bands arranged symmetrically about the axis of the oceanic ridge.
  4. As basaltic rocks crystallize, some minerals align themselves with Earth's magnetic field, as it exists at that time, imparting a permanent magnetic field, called **paleomagnetism**, to the rock.
  5. Periodically Earth's **magnetic field polarity** (direction) reverses poles.
    - a. Field polarity as it is today is called **normal polarity**. North Pole polarity is positive and South Pole polarity is negative.
    - b. Opposite field polarity is called **reverse polarity**. North Pole polarity is negative and South Pole polarity is positive.
- E. Because of their paleomagnetism, rocks of the sea floor influence the magnetic field recorded by magnetometers.
1. Rocks on the sea floor with normal polarity paleomagnetism locally reinforce Earth's magnetic field making it stronger and producing a **positive anomaly**.
  2. Rocks on the sea floor with reverse paleomagnetism locally weaken Earth's magnetic field, producing a **negative anomaly**.
  3. Rocks forming at the ridge crest record the magnetism existing at the time they solidify.
    - a. The next rifting divides them with part being added to each side of the widening sea floor.
    - b. This produces symmetrical bands of magnetic anomalies across the ocean basin.
  4. Sea floor increases in age away from the ridge and is more deeply buried by sediment because sediments have had a longer time to collect.
  5. Rates of sea-floor spreading vary from 1 to 10 cm per year for each side of the ridge and can be determined by dating the sea floor and measuring its distance from the ridge crest.
  6. Continents are moved by the expanding sea floor.

### 3-3. Global Plate Tectonics

- F. Because Earth's size is constant, expansion of the crust in one area requires destruction of the crust elsewhere.
1. Currently, the Pacific Ocean basin is shrinking as other ocean basins expand.
  2. Destruction of sea floor occurs in **subduction zones**.
  3. **Seismicity** is the frequency, magnitude, and distribution of earthquakes.
    - Earthquakes are concentrated along oceanic ridges, transform faults, trenches and island arcs.
  4. **Tectonism** refers to the deformation of Earth's crust.
  5. **Benioff Zone** is an area of increasingly deeper seismic activity, inclined from the trench downward in the direction of the island arc.
- d. **Subduction** is the process at a trench whereby one part of the sea floor plunges below another and down into the asthenosphere.
- a. As the rocks scrape past each other they generate earthquakes.
  - b. In the asthenosphere the sea floor melts and the molten material rises, melting through the overlying plate, forming the **andesitic** volcanoes of the island arc.
- G. Earth's surface is composed of a series of **lithospheric plates**. Plate edges extend through the lithosphere and are defined by seismicity.
1. Plate edges are trenches, oceanic ridges, and transform faults.
  2. Seismicity and volcanism are concentrated along plate boundaries.
  3. Movement of plates is caused by **thermal convection** of the "plastic" rocks of the asthenosphere that drag along the overlying lithospheric plates.

4. **Mantle plumes** originate deep within the asthenosphere as molten rock that rises and melts through the lithospheric plate forming a large volcanic mass at a "**hot spot**."
- a. "Hot spots" are in the interior of a plate, not at the edges.
  - b. Plate motion progressively moves the volcanic mass away from the mantle plume and a new volcano develops above the hot spot.
  - c. A linear series of volcanoes form indicating past direction of plate motion.
  - d. Only volcanoes closest to the "hot spot" are still active.

- H. **Wilson Cycle** refers to the sequence of events leading to the formation, expansion, contracting and eventual elimination of ocean basins.
- Stages in basin history are:
    1. **Embryonic**—rift valley forms as continent begins to split.
    2. **Juvenile**—sea floor basalts begin forming as continental sections diverge.
    3. **Mature**—broad ocean basin widens, trenches develop, and subduction begins.
    4. **Declining**—subduction eliminates much of sea floor and oceanic ridge.
    5. **Terminal**—last of the sea floor is eliminated and continents collide forming a continental mountain chain.