1 **CHAPTER 2**
Plate Tectonics and the Ocean Floor

2 **Chapter Objectives**
- Describe the evidence Alfred Wegener used to formulate his idea of continental drift.
- Understand how the early idea of continental drift differs from the more modern version of plate tectonics.
- Cite lines of evidence that support the theory of plate tectonics.
- Know about the use of Global Positioning Satellite System to measure plate motion.

3 **Chapter Objectives (continued)**
- Identify geographic examples and discuss features associated with the three types of plate boundaries:
  - divergent (including both continental and oceanic rifting)
  - convergent (including the following subtypes):
    - ocean-continent
    - ocean-ocean
    - continent-continent
  - transform

4 **Chapter Objectives (continued)**
- Explain how hotspots and mantle plumes fit into the plate tectonic model.
- Know about the Wilson Cycle of ocean basin evolution.
- Understand how ocean islands evolve and relate to plate tectonics.
- Understand how plate tectonics and continental drift have made the continents and ocean basins different in the past and will continue to make them different in the future.

5 **Plate Tectonics, or the new global geology**
- Thin, rigid blocks move horizontally
- Interactions of plates build major features of Earth's crust

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7 **Plate tectonics explains:**
- Global distribution of
  - Volcanoes
  - Earthquakes
  - Faults
  - Mountain belts
  - Features of seafloor
- Evolution of continents and oceans

8 **Continental drift**
- Wegener proposed one large continent (1912)
  - Pangaea
- Surrounded by single large ocean
  - Panthalassa
- About 200 million years ago

9 **Alfred Lothar Wegener**

10 **Present-day Configuration**

11 **200 million years ago**

12 **Evidence for continental drift**
- Puzzle-like fit of continents
  - Edward Bullard fit continents at 2000m water depth

13 **Evidence for continental drift**
- Matching sequences of rocks and mountain chains
  - Similar age, rock types, structures

14 **Present Day**

15 **About 300 million years ago**

16

- Glacial ages and other climate evidence
  - Ancient glaciation in modern tropical regions
  - Direction of glacial flow

17 **Present Day**

18 **About 300 million years ago**

19

- Distribution of organisms
  - Same land animals distributed in different continents (e.g., South America and Africa)

20 **Mesosaurus fossils**

21 **Fossil evidence**

- The same fossils are found in both South America and Africa
- Fresh water fish cannot migrate through oceans
- Swamp evidence is found in Antarctica

22 **Objections to continental drift**

- Continents cannot “plow” through ocean crust
- Gravitational forces associated with tides too small
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23 **Evidence for plate tectonics**

- Earth’s magnetic field
- Paleomagnetism
  - Magnetic alignment (N or S)
  - Magnetic inclination (magnetic dip)
    - Latitude

24 **Earth’s Magnetic Field**

25 **Magnetic Inclination vs. Latitude**

26 **Figure 2.10**

27 **Apparent polar wandering**

28 **Apparent polar wandering**

29 **Observed:**

30 **Reconstructed:**

31 **Magnetoreception**

- One of the navigation tools used by green sea turtles?

32 **Paleomagnetism**

33 **Sea floor spreading**

- Harry Hess: (1962)
  - Mid-ocean ridge site of new ocean crust
  - Oceanic trench site of crust destruction (subduction)

34 **Sea-Floor Spreading and Plate Boundaries**

35 **Evidence to support sea floor spreading**

- Parallel magnetic anomalies record changes in Earth’s magnetic polarity as sea floor created
- Age of ocean floor increases away from crest of mid-ocean ridge

36

37 **Magnetic anomalies**

38 **Evidence to support sea floor spreading**

- Heat flow is highest at crest of mid-ocean ridge

- Most large earthquakes occur along plate margins

39 **Global distribution of earthquakes**

40 **Earthquake Distribution**

41 **Plate Boundaries, Spreading Rates**

42 **Plate tectonics theory**

- Lithospheric plates “float” on the asthenosphere
- Large scale geologic features occur at plate boundaries
- Two major tectonic forces
  - Slab pull
  - Slab suction

43 **Types of plate boundaries**

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- Plates move apart
- Mid-ocean ridge
  - Rift valley
- New ocean floor created
- Shallow earthquakes

45 **Rift Valley in Iceland**

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47 **Types of spreading centers**

- Oceanic rise
  - Fast-spreading
  - Gentle slopes
- Oceanic ridge
  - Slow-spreading
  - Steep slopes
- Ultra-slow
  - Deep rift valley
  - Widely scattered volcanoes

48 **Slow vs. Fast:**

49 **Slow spreading:**

50 **Fast Spreading:**

51 **Figure 2.18a**

52 **Figure 2.18b**

53 **Three types of convergent plate boundaries:**

54

- Oceanic-continental convergence
  - Ocean plate subducted
  - Continental arc
  - Oceanic trench
  - Deep earthquakes

55 **Ocean-Continent Collision**

56 **Cascadia:**

57 **Mt. St. Helens**

58 **May 18th, 1980**

59 **NEPTUNE Project**

60 **Figure 2.15**

61 **Ocean-Ocean boundary features**

- Plates move toward each other
- Oceanic crust destroyed
  - Ocean trench
  - Volcanic arc

- Deep earthquakes

62 **Ocean-Ocean Collision**

63 **Types of convergent boundaries**

- Continental-continental convergence
  - Uplifted mountain ranges
  - Deep earthquakes

64 **Continent-Continent Collision**

65 **45 million years ago**

66 **Today**

67 **Converging Margins: India-Asia Collision**

68 **Satellite View of the Himalayas**

69 **Transform boundary features**

- Offsets oriented perpendicular to mid-ocean ridge
  - Segments of plates slide past each other
- Offsets permit mid-ocean ridge to move apart at different rates
- Shallow but strong earthquakes

70 **Types of transform faults**

- Oceanic—wholly in ocean floor
- Continental—extends from mid-ocean ridge across continent

71 **Figure 2.23a**

72 **Transform Faults**

73 ***Transform fault boundary***

74

75

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77 **Applications of plate tectonics model to intraplate features**

- Mantle plumes and hotspots
  - Volcanic islands within a plate
  - Island chains
  - Systematic variation of age
- Record ancient plate motions

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82 **Applications of plate tectonics model to intraplate features**

- Seamounts and tablemounts
  - Subsidence of flanks of mid-ocean ridge
  - Wave erosion may flatten seamount

83 **Formation of seamounts and guyots**

84 **Applications of plate tectonics model to intraplate features**

- Coral reefs associated with subsiding seafloor
- Fringing
- Barrier
- Atoll

85 **Development of coral reefs**

86 **Great Barrier Reef**

87 **Figure 2.29**

88 **Measuring plate motion by satellites**

89 **Paleoceanography**

- Reconstructing paleogeography

- Continental accretion
  - Continental material added to edges of continents through plate motion
- Continental separation or rifting
  - Continents move apart

90 **Paleo-reconstructions**

91 **Gaze into the crystal ball…**

92 **Break up of Pangaea**

93 **Future predictions**

- Future positions of continents and oceans
  - Assume same direction and rate of plate motions as now

94 **World map 50 million years from now**

95 **Wilson cycle**

- John Tuzo Wilson
- Life cycle of ocean basins
  - Formation
  - Growth
  - Destruction

96

97 **End of Chapter 2 -**
Plate Tectonics and the Ocean Floor