1 **CHAPTER 3**
Marine Provinces

2 **Chapter Overview**

- The study of bathymetry determines ocean depths and ocean floor topography.
- Echo sounding and satellites are efficient bathymetric tools.
- Most ocean floor features are generated by plate tectonic processes.
- Different sea floor features exist in different oceanographic locations.

3

4 **Bathymetry**

- Measures the vertical distance from the ocean surface to mountains, valleys, plains, and other sea floor features
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5 **Measuring Bathymetry**

- Soundings
  - Poseidonus made first sounding in 85 B.C.
  - Line with heavy weight
  - Sounding lines used for 2000 years
- Fathom
  - Unit of measure
  - 1.8 meters (6 feet)

6 **Measuring Bathymetry**

- *HMS Challenger*
  - Made first systematic measurements in 1872
- Deep ocean floor has relief
  - Variations in sea floor depth
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7 **Measuring Bathymetry**

- Echo Soundings
  - Echo sounder or fathometer
  - Reflection of sound signals
  - German ship *Meteor* identified mid-Atlantic ridge in 1925
- Lacks detail
- May provide inaccurate view of sea floor
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8 **Echo Sounding Record**

9 **Measuring Bathymetry**

- Precision Depth Recorder (PDR)
  - 1950s
  - Focused high-frequency sound beam
  - First reliable sea floor maps produced
  - Helped confirm sea floor spreading
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10 **Modern Bathymetry Measuring**

- Multibeam Echo Sounders
  - Multiple simultaneous sound frequencies
- Seabeam
  - First multibeam echo sounder
  - Map sea floor strips up to 60 km (37 mi) wide

11 **Modern Bathymetry Measuring**

- SONAR

– "SOund Navigation And Ranging" (acronym)

12 **Modern Bathymetry Measuring**
- Side scan sonar
  - GLORIA (Geological Long-range Inclined Acoustical instrument)
  - Sea MARC (Sea Mapping and Remote Characterization)
- Can be towed behind ship to provide very detailed bathymetric strip map
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13 **GLORIA Side Scanning Sonar**

14 **Sea Floor Mapping from Space**
- Uses satellite measurements
- Measures sea floor features based on gravitational bulges in sea surface
- Indirectly reveals bathymetry
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15 **Ship bathymetry**

16 **Satellite bathymetry**

17 **Sea Floor Mapping from Space**
- Satellite-derived ocean surface gravity
- Reveals bathymetry where ships have not conducted research
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18 **Measuring Bathymetry**
- Seismic Reflection Profiles
  - Air guns
  - Strong, low-frequency sounds
  - Details ocean structure beneath sea floor
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19 **Seismic Reflection Profile**

20 **Hypsographic Curve**
- Shows relationship between height of land and depth of ocean
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21 **Hypsographic Curve**
- 70.8% of Earth covered by oceans
- Average ocean depth is 3729 meters
- Average land elevation is 840 meters
- Uneven distribution of areas of different depths/elevations
- Variations suggest plate tectonics at work

22 **Ocean Provinces**

Three Major Provinces
- Continental margins
  - Shallow-water areas close to shore
- Deep-ocean basins
  - Deep-water areas farther from land
- Mid-ocean ridge
  - Submarine mountain range

23 **Ocean Provinces**

24 **Continental Margins**
- Passive
  - Not close to any plate boundary
  - No major tectonic activity
  - East coast of United States
- Active

  - Associated with convergent or transform plate boundaries
  - Much tectonic activity
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- 25 **Passive and Active Continental Margins**
- 26 **Active Continental Margins**
  - Convergent Active Margin
    - Oceanic-continent convergent plate boundaries
    - Active continental volcanoes
    - Narrow shelf
    - Offshore trench
    - Western South America
- 27 **Active Continental Margins**
  - Transform Continental Margin
    - Less common
    - Transform plate boundaries
    - Linear islands, banks, and deep basins close to shore
    - Coastal California along San Andreas Fault
- 28 **Continental Margin Features**
  - Continental shelf
  - Shelf break
  - Continental slope
  - Continental rise
  -
- 29 **Passive Continental Margin Features**
- 30 **Continental Shelf**
  - Flat zone from shore to shelf break
    - Shelf break is where marked increase in slope angle occurs.
  - Geologically part of continent
  - Average width is 70 km (43 miles) but can extend to 1500 km (930 miles)
  - Average depth of shelf break is 135 meters (443 feet)

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- 31 **Continental Shelf**
  - Type of continental margin determines shelf features.
  - Passive margins
    have wider shelves.
  - California's transform active margin
    has a continental borderland.
- 32
- 33 ***How the Continental Borderland came to be...***
- 34 **Continental Slope**
  - Where deep ocean basins begin
  - Topography similar to land mountain ranges
  - Greater slope than continental shelf
    - Averages 4˚ but varies from 1–25˚ gradient
  - Marked by submarine canyons
- 35 **Submarine Canyons**
  - Narrow, deep, V-shaped in profile
  - Steep to overhanging walls
  - Extend to base of continental slope,
    3500 meters (11,500 feet) below sea level

- Carved by turbidity currents

36 **Turbidity Currents**
- Underwater avalanches mixed with rocks and other debris
- Sediment from continental shelf
- Moves under influence of gravity
- Sediments deposited at slope base

37 **Continental slope and submarine canyons**

38 **LaJolla Submarine Canyon**

39 **Continental Rise**
- Transition between continental crust and oceanic crust
- Marked by turbidite deposits from turbidity currents
- Graded bedding in turbidite deposits

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40 **Continental Rise**
- Deposits generate deep-sea fans, or submarine fans
- Distal ends of submarine fans become flat abyssal plains

41 **Abyssal Plains**
- Extend from base of continental rise
- Some of the deepest, flattest parts of Earth
- Suspension settling of very fine particles
- Sediments cover ocean crust irregularities
- Well-developed in Atlantic and Indian oceans
-

42 **Abyssal Plains**

43 **Abyssal Plain Volcanic Peaks**
- Poke through sediment cover
- Below sea level:
  - Seamounts, tablemounts, or guyots *at least* 1 km (0.6 mile) above sea floor
  - Abyssal hills or seaknolls are *less than* 1 km (0.6 mile) above sea floor
- Above sea level:
  - Volcanic islands
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44 **Ocean Trenches and Volcanic Arcs**
- Convergent margins generate ocean trenches.
  - Deepest part of oceans
  - Most in Pacific Ocean
  - Deepest trench – Mariana Trench at 11,022 meters (36,161 feet)
-

45 **Ocean Trenches**

46 **Island and Continental Arcs**
- Volcanic arc on non-subducted plate
- Island arc
  - Islands in ocean (Japan)
- Continental arc
  - Mountains on land (Andes Mountains)

47 **Pacific Ring of Fire**
- Margins of Pacific Ocean

- Majority of world's active volcanoes and earthquakes
- Marked by convergent boundaries

48 **Mid-Ocean Ridge**
- Longest mountain chain
- On average, 2.5 km (1.5 miles) above surrounding sea floor
- Volcanic
- Basaltic lava
- Divergent plate boundary
-

49 ***Mid-Ocean Ridge***

50 **Mid-Ocean Ridge Features**
- Rift Valley
  - Downdropped area on crest of ridge
  - Marked by fissures and faults
  - Small earthquakes
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51 **Mid-Ocean Ridge Features**
- Seamounts – tall volcanoes

52 **Mid-Ocean Ridge Features**
- Pillow lava or pillow basalt
  - shapes formed when hot basaltic lava quickly cools

53 **Mid-Ocean Ridge Features**

Hydrothermal Vents
- Sea floor hot springs
- Foster unusual deep-ocean ecosystems able to survive without sunlight

54 **Hydrothermal Vents**
- Warm water vents – temperatures below 30˚C (86˚F)
- White smokers – temperatures from 30–350˚C (86–662˚F)
- Black smokers – temperatures above 350˚C (662˚F)

55 **Hydrothermal Vents**

56 **Fracture Zones and Transform Faults**
- Transform faults along mid-ocean ridge offset spreading zones.
  - Linear ridge on spherical Earth
  - Seismically active
- Fracture zones along Pacific Ocean mid-ocean rise
  - Seismically inactive
  - Occur beyond offset fragments of rise
-

57 **Fracture Zones**

58 **Fracture Zones and Transform Faults**

59 **Fracture Zones and Transform Faults**

60 **Oceanic Islands**
- Types:
  - Volcanic activity (random?)
  - Hotspots
  - Island arcs
  - Islands that are part of continents

61 **End of CHAPTER 3**

Marine Provinces