CHAPTER 3
Marine Provinces

Chapter Overview
- The study of bathymetry charts ocean depths and ocean floor topography.
- Echo sounding and satellites are efficient bathymetric tools.
- Most ocean floor features are generated by plate tectonic processes.

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

Measuring Bathymetry
- Soundings
  - Poseidonus first sounding 85 B.C.
  - Line with heavy weight
  - Sounding lines used for 2000 years
- Unit of measure is a fathom
  - 1.8 meters (6 feet)
- First systematic measurements – HMS Challenger 1872

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

Echo Sounding Record
Measuring Bathymetry

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

Modern Acoustic Instruments

- **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
  - Multi-beam echo sounder
  - Seabeam

Side Scanning Sonar

Sea Floor Mapping from Space

- Uses satellite measurements
- Measures sea floor features based on gravitational bulges in sea surface
- Indirectly reveals bathymetry

Seismic Reflection Profiles

- Air guns
- Strong, low-frequency sounds
- Details ocean structure beneath sea floor

Seismic Reflection Profile
Hypsographic Curve

- Shows relationship between height of land and depth of ocean

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

Continental Margins

- Passive or Active
- Passive
  - Not close to any plate boundary
  - No major tectonic activity
  - Example: East coast of United States
- Active
  - Associated with convergent or transform plate boundaries
  - Much tectonic activity

Active Continental Margins

Convergent or Transform
- Convergent Active Margin
  - Oceanic-continent convergent plate boundaries
  - Active continental volcanoes
  - Narrow shelf
  - Offshore trench
  - Example: Western South America
Active Continental Margins

- Transform Continental Margin
  - Less common
  - Transform plate boundaries
  - Linear islands, banks, and deep basins close to shore
  - Example: Coastal California along San Andreas Fault

Continental Margin Features

- Continental shelf
- Shelf break
- Continental slope
- Continental rise

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)
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

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

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

Continental Rise
- Transition between continental crust and oceanic crust
- Marked by turbidite deposits from turbidity currents
- Graded bedding in turbidite deposits
- Deposits generate deep-sea fans, or submarine fans
- Distal ends of submarine fans become flat abyssal plains

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

Abyssal Plains
- Graded bedding in turbidite deposits
- Deposits generate deep-sea fans, or submarine fans
- Distal ends of submarine fans become flat abyssal plains
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 seamounts are less than 1 km (0.6 mile) above sea floor
• Above sea level:
  – Volcanic islands

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)
• Volcanic arc on nonsubducted ocean plate
  – May produce island arc, e.g., Japan
• Continental arc on land

Pacific Ring of Fire

• Margins of Pacific Ocean
• Majority of world's active volcanoes and earthquakes
• Marked by convergent boundaries

Ocean Trenches and Ring of Fire

Mid-Ocean Ridge

• Longest mountain chain
• On average, 2.5 km (1.5 miles) above surrounding sea floor
• Wholly volcanic
• Basaltic lava
• Divergent plate boundary

Mid-Ocean Ridge
Mid-Ocean Ridge Features

- Central rift valley downdropped by seafloor spreading
  - Fissures and faults in rift valley
- Seamounts – tall volcanoes
- Pillow lava or pillow basalt – shapes formed when hot basaltic lava quickly cools

Hydrothermal Vents

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

Fracture Zones and Transform Faults

<table>
<thead>
<tr>
<th>Fracture Zones</th>
<th>Transform faults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane boundary?</td>
<td>Yes – transform plate boundary</td>
</tr>
<tr>
<td>Relative movement axes feature</td>
<td>Movement in opposite directions</td>
</tr>
<tr>
<td>Fracture zone?</td>
<td>Yes – transform fault zone</td>
</tr>
<tr>
<td>Relationship to mid-ocean ridge</td>
<td>Occurs between offset mid-ocean ridge segments</td>
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<tr>
<td>Geographic examples</td>
<td>East Pacific Rise, Mid-Atlantic Ridge, Reykjanes Ridge, East Pacific Rise, Hess, Atlantis, Endeavour, Juan de Fuca Plate, Emperor Seamounts</td>
</tr>
</tbody>
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Transform Faults and Fracture Zones
Oceanic Islands

- Volcanic activity
- Hotspots
- Island arcs

End of CHAPTER 3
Marine Provinces