

# Chapter 3 Lecture

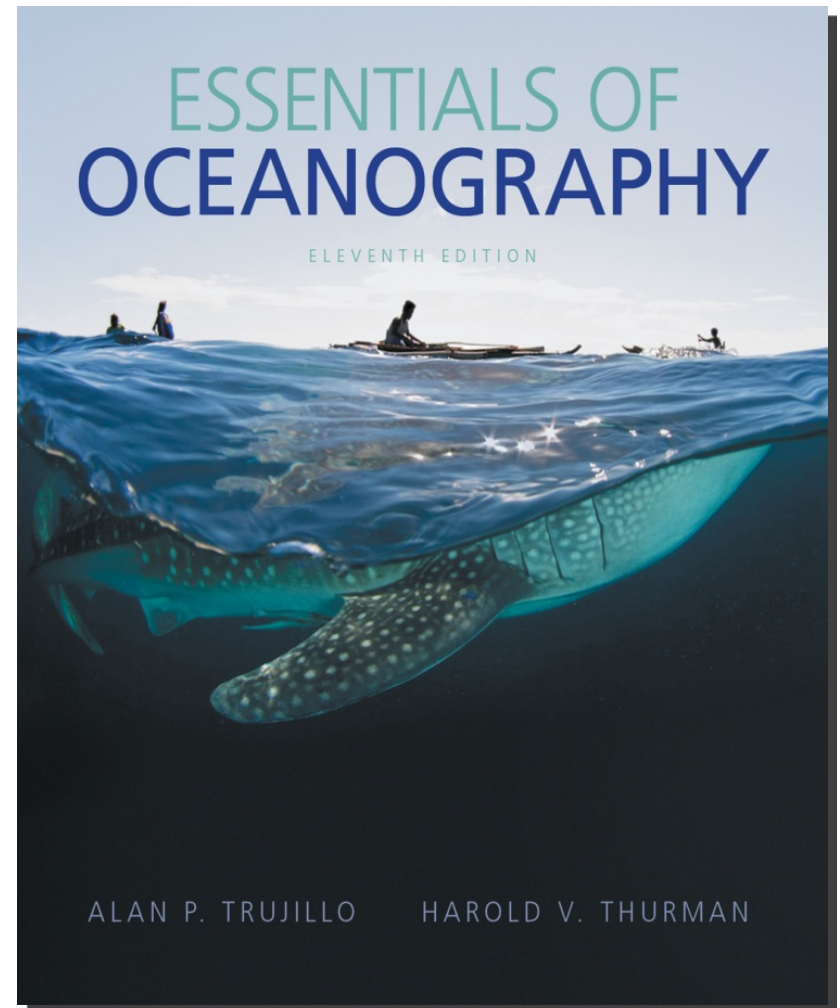
# Essentials of Oceanography

Eleventh Edition

## Marine Provinces

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# 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.

# Bathymetry

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

# 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)

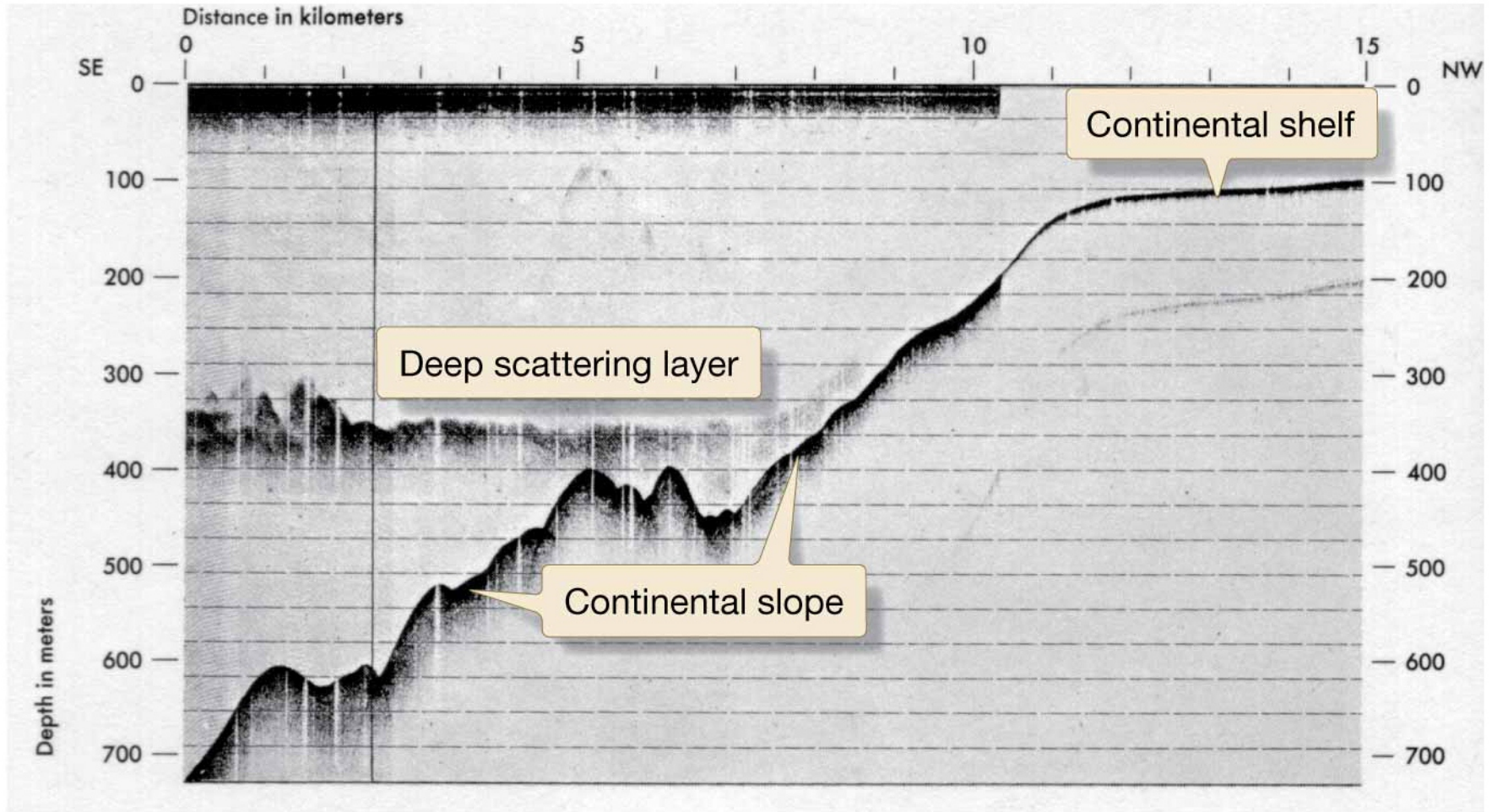
# Measuring Bathymetry

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

# 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

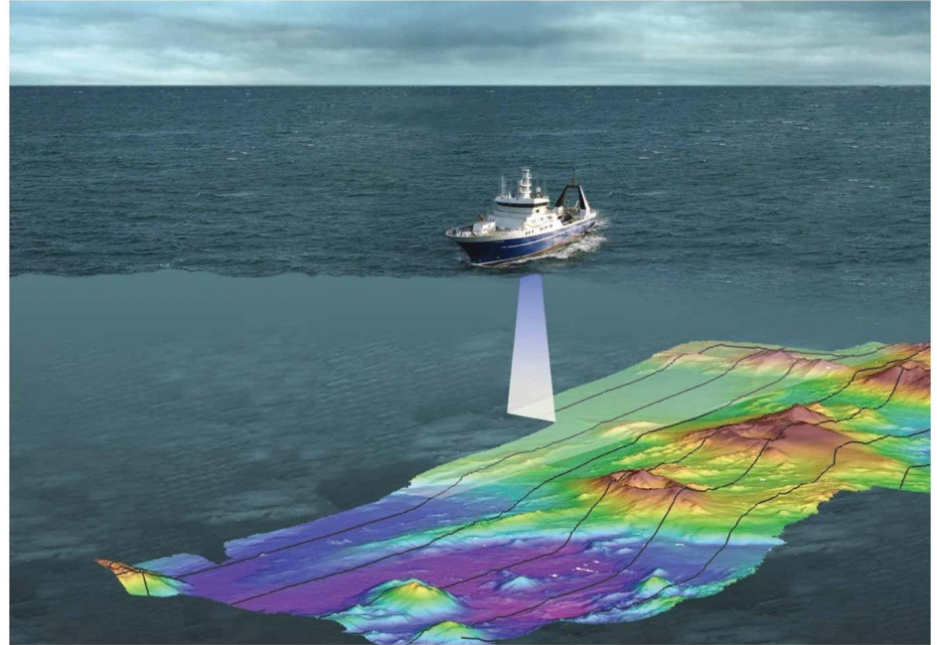


# Measuring Bathymetry

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

# Modern 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



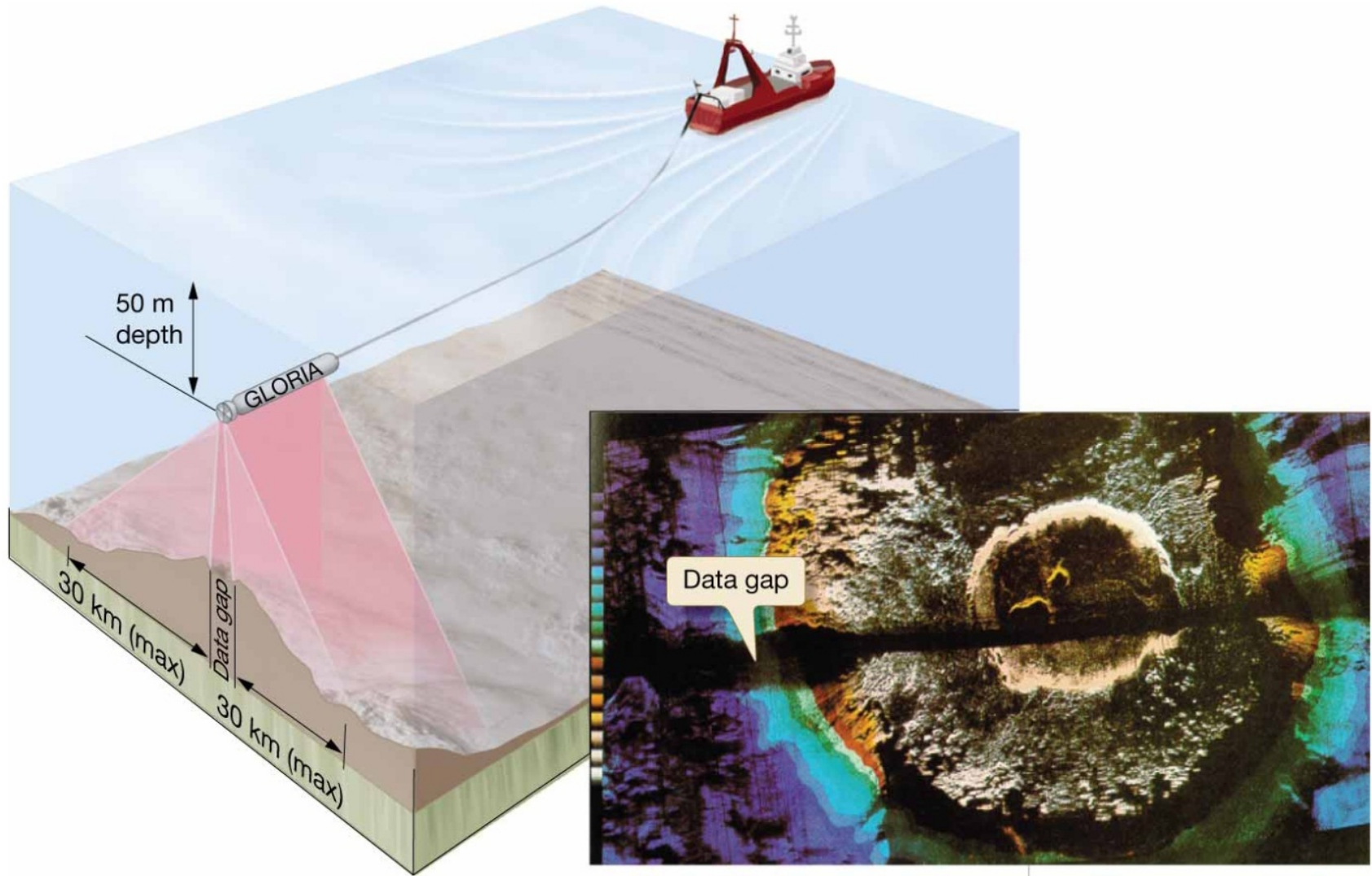
# Modern Bathymetry Measuring

- **Sonar**
  - Sound navigation and ranging acronym

# Modern Bathymetry Measuring

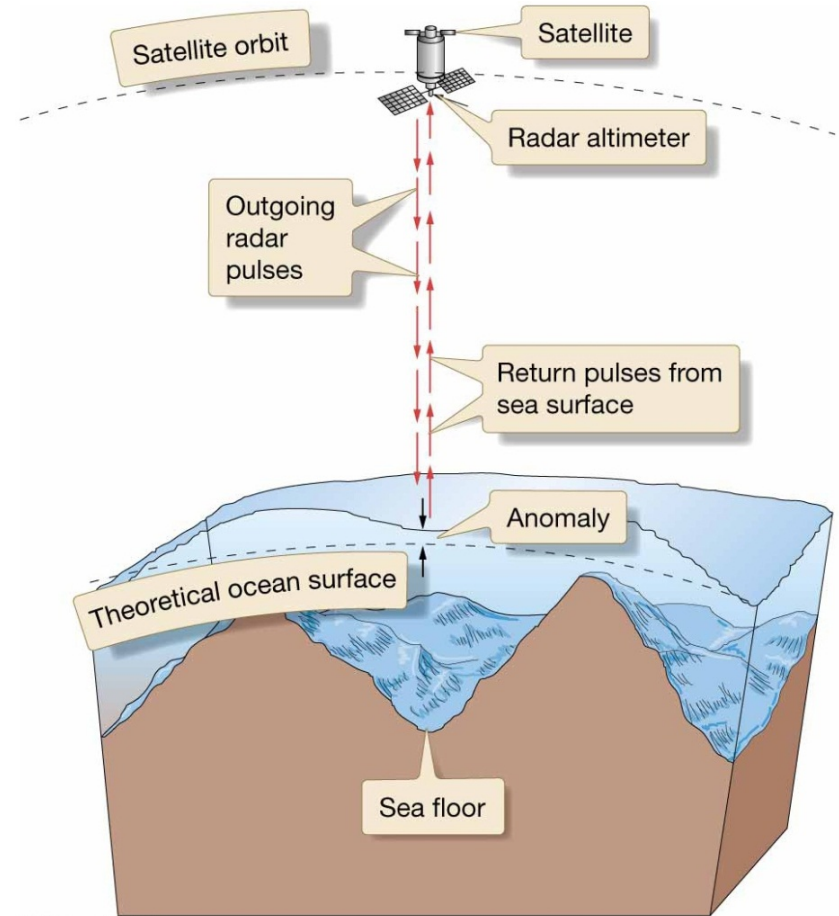
- Side scan sonar
  - **GLORIA** (Geological Long-range Inclined Acoustical instrument)
  - **Sea MARC** (Sea Mapping and Remote Characterization)
- Can be towed behind ship to provide very detailed bathymetric strip map

# GLORIA Side Scanning Sonar

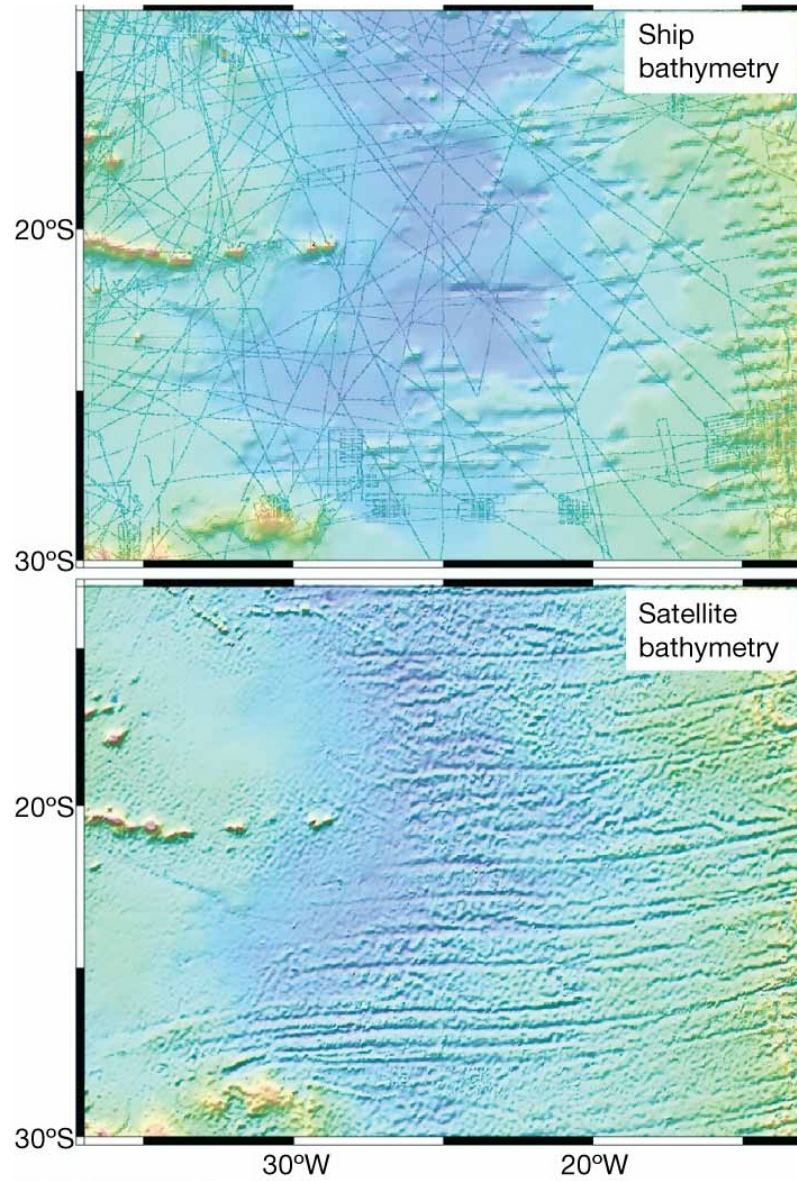


# Sea Floor Mapping from Space

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

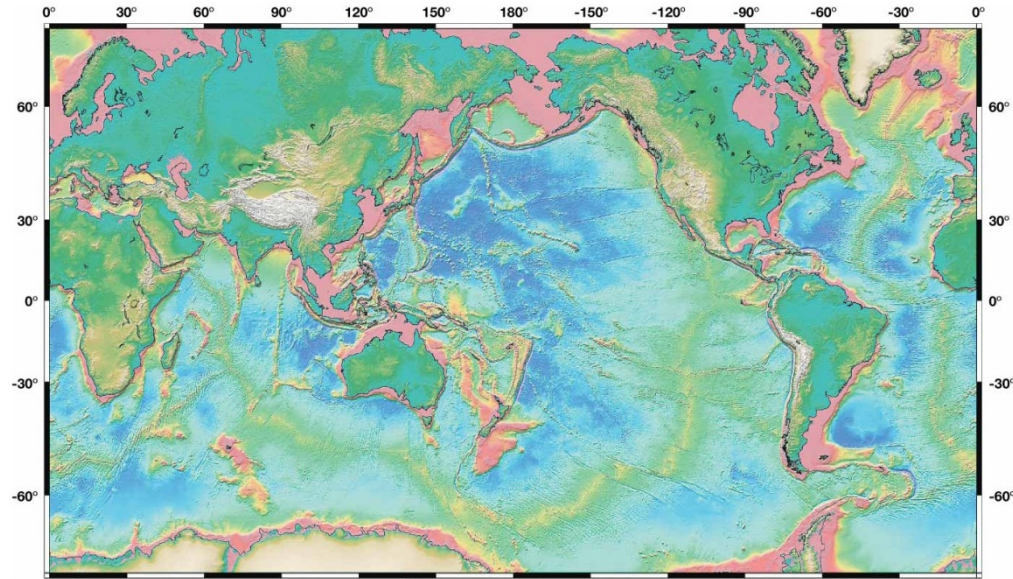


# Comparing Bathymetric Maps



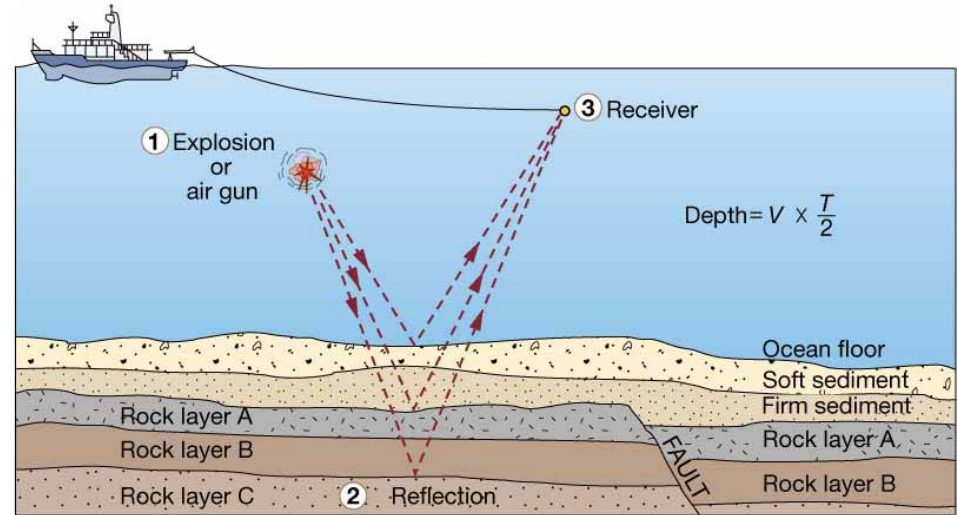
# Sea Floor Mapping from Space

- Satellite-derived ocean surface gravity
- Reveals bathymetry where ships have not conducted research

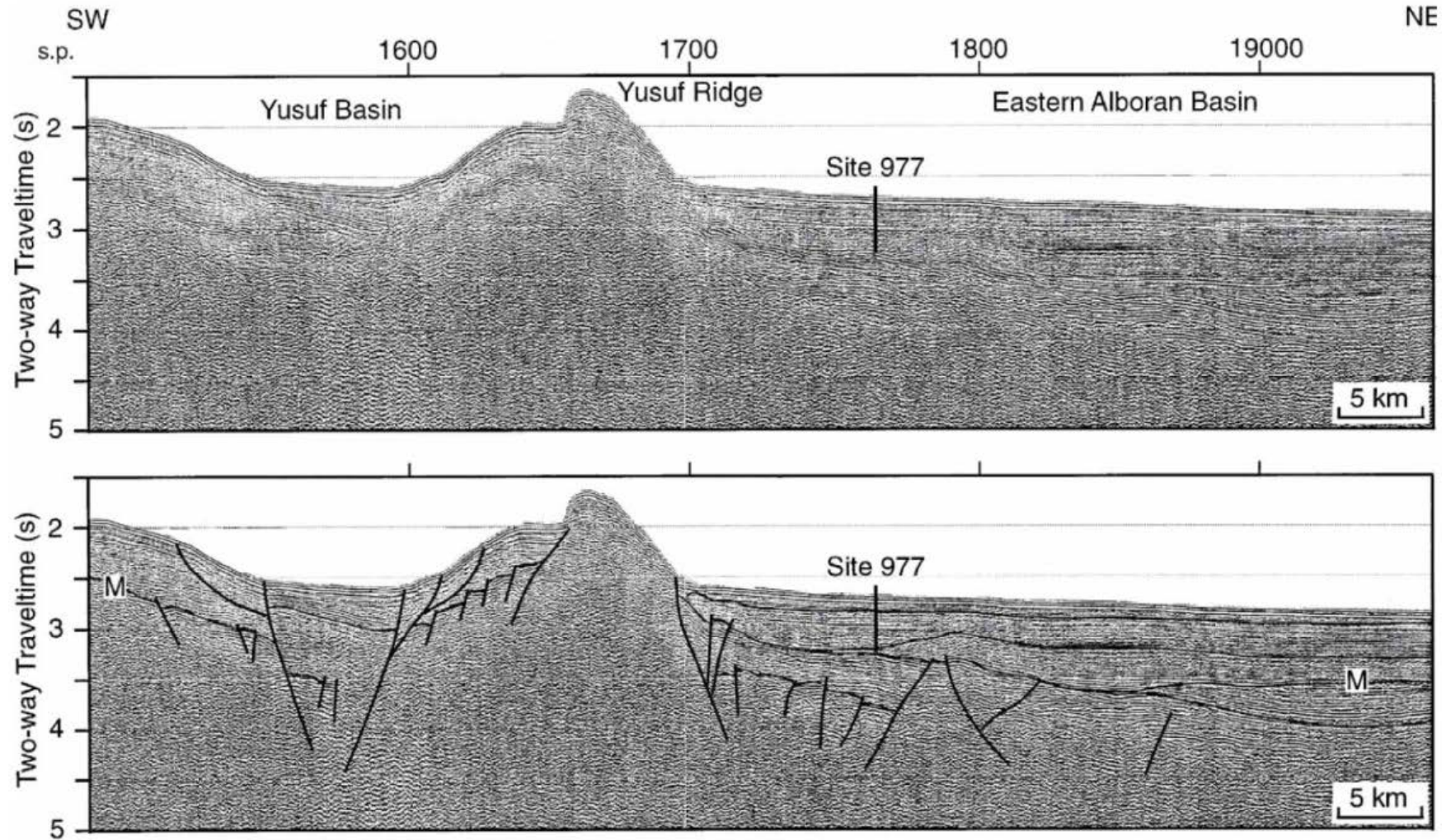


# Measuring Bathymetry

- **Seismic Reflection Profiles**
  - Air guns
  - Strong, low-frequency sounds
  - Details ocean structure beneath sea floor

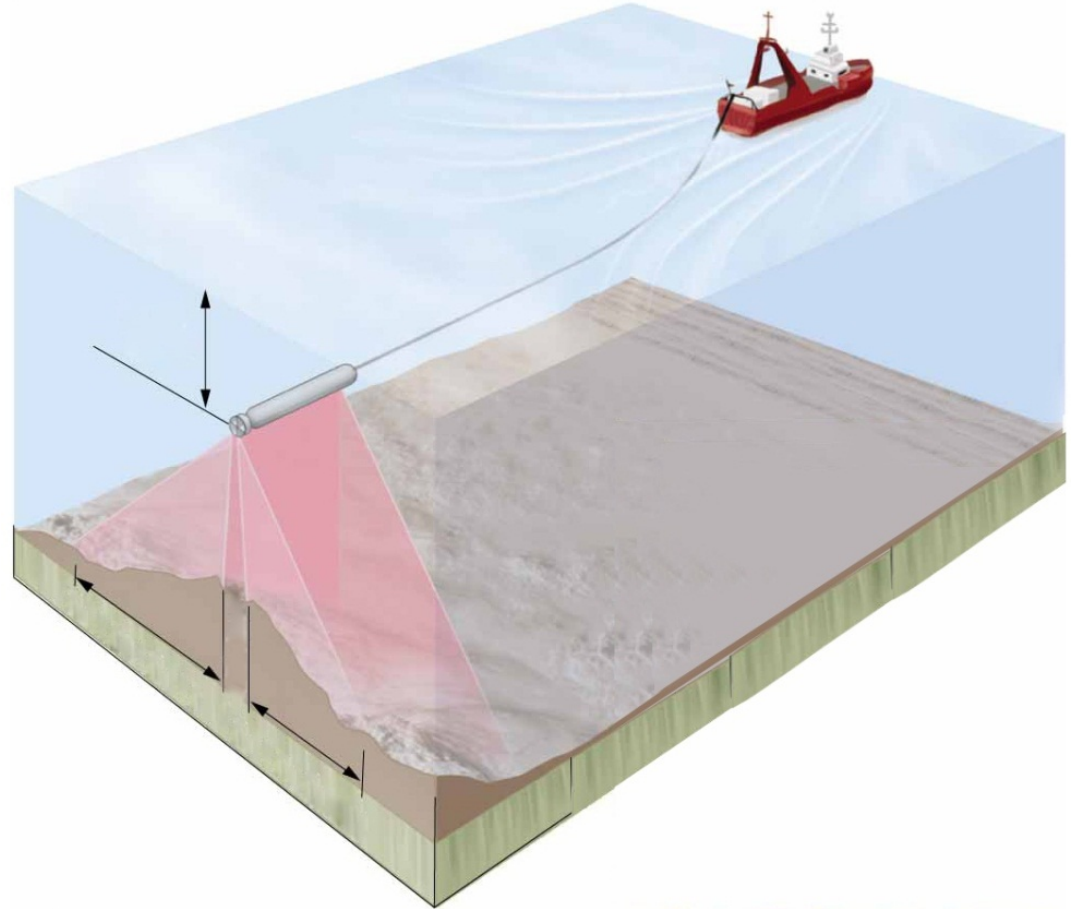


# Seismic Reflection Profile



# Hypsographic Curve

- Shows relationship between height of land and depth of ocean



# Hypsographic Curve

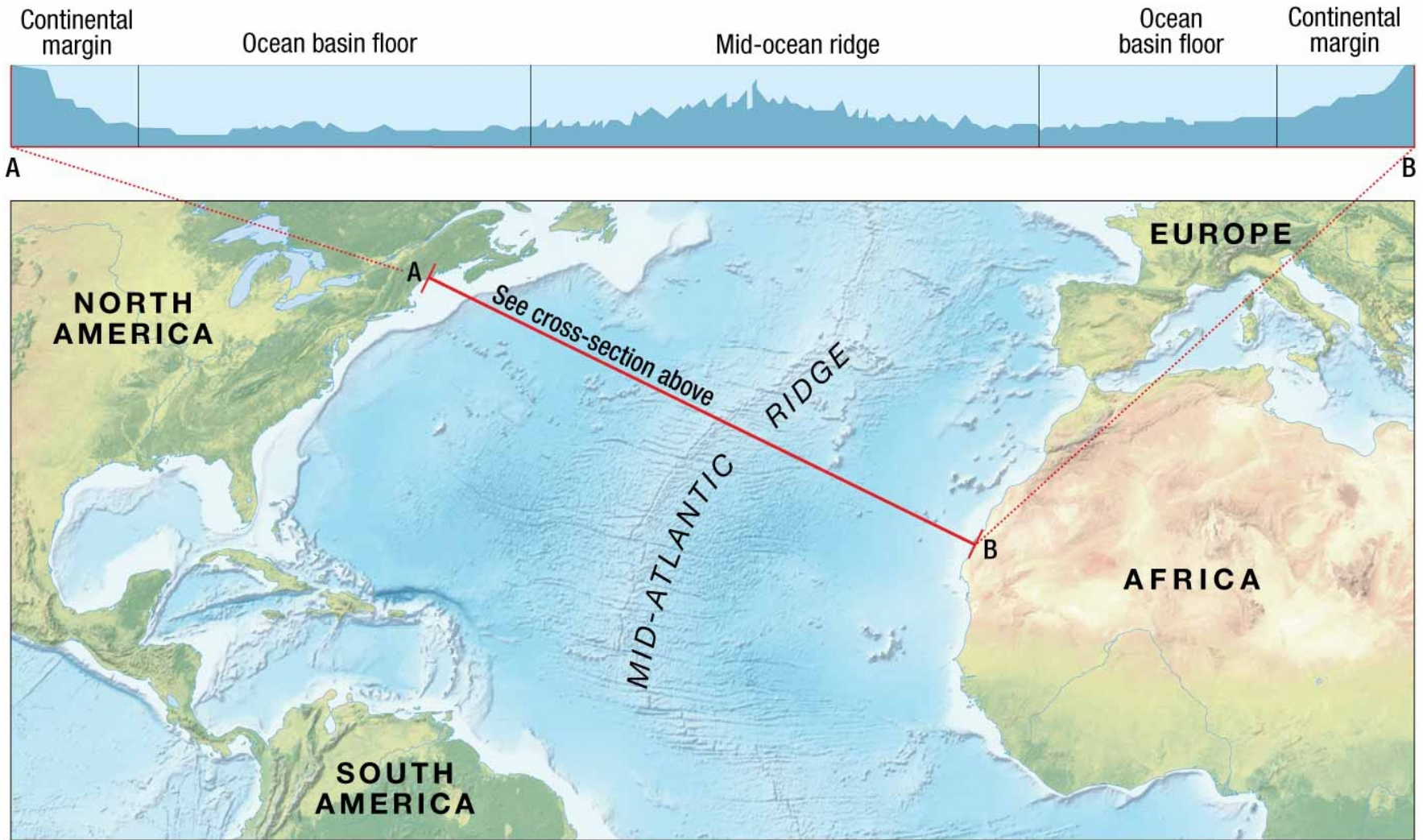
- 70.8% of Earth covered by oceans
- Average ocean depth is 3729 meters
- Average land elevation is 840 meters
- Uneven distribution of areas of different depths/elevations
- Variations suggest plate tectonics at work

# 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

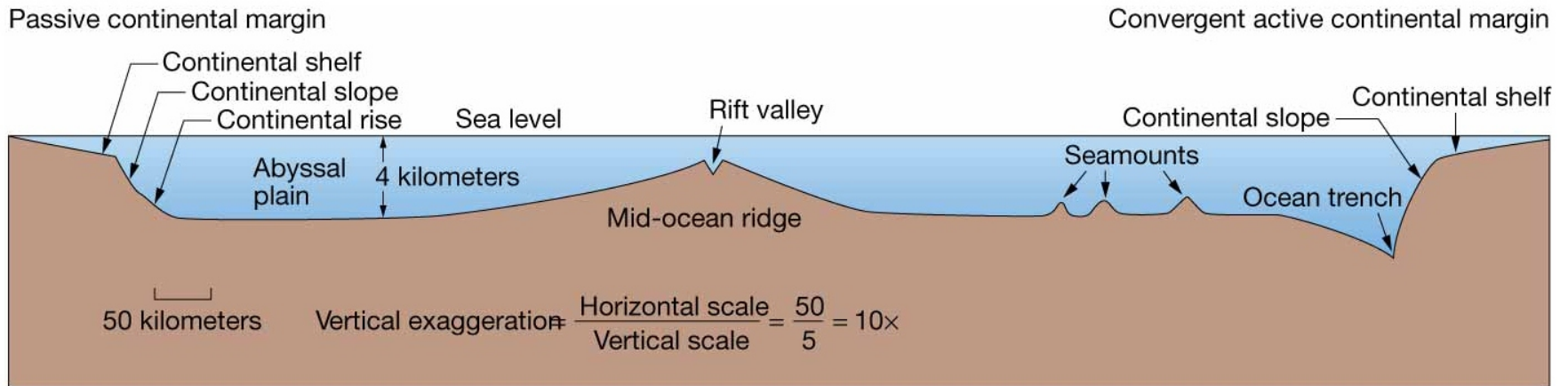
# Ocean Provinces



# 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

# Passive and Active Continental Margins



# Active Continental Margins

- **Convergent Active Margin**
  - Oceanic-continent convergent plate boundaries
  - Active continental volcanoes
  - Narrow shelf
  - Offshore trench
  - Western South America

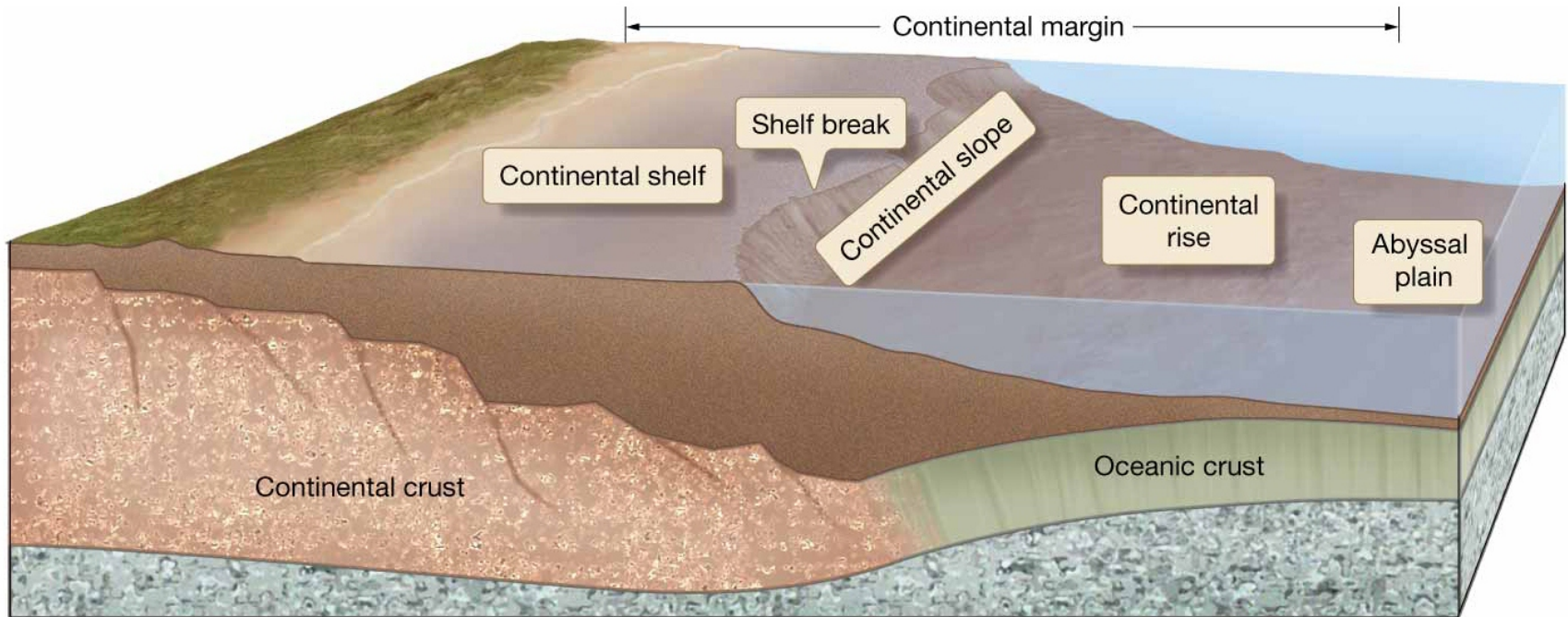
# Active Continental Margins

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

# Continental Margin Features

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

# Passive Continental Margin Features

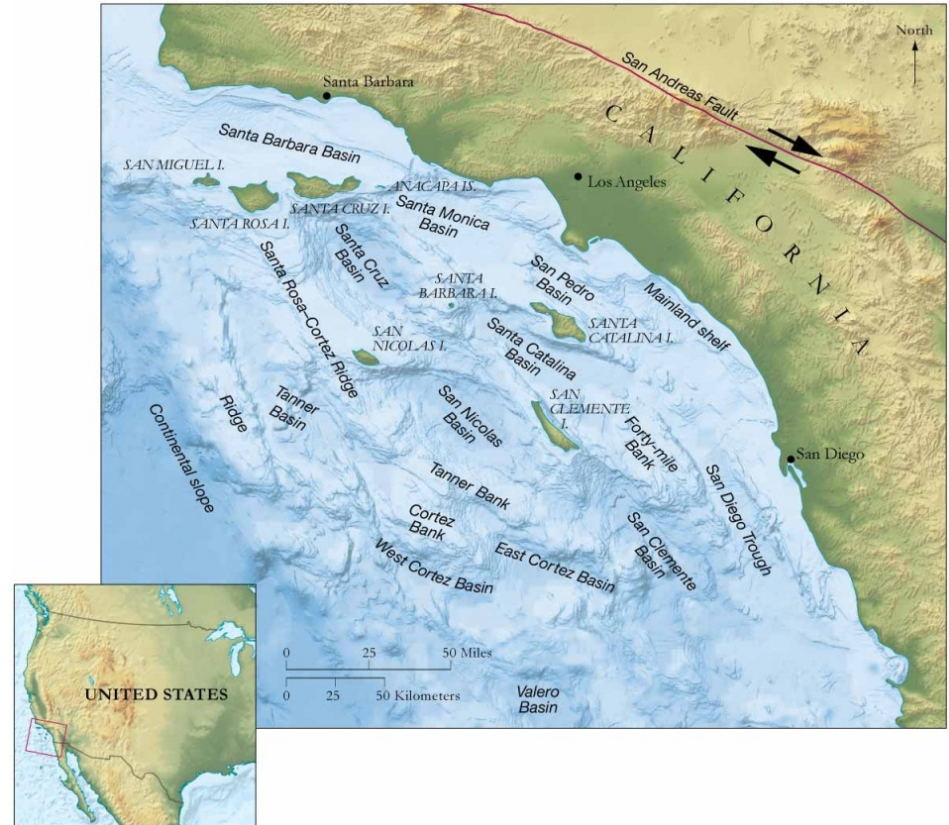


# Continental Shelf

- 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 Shelf

- Type of continental margin determines shelf features.
- Passive margins have wider shelves.
- California's transform active margin has a **continental borderland**.



# Continental Slope

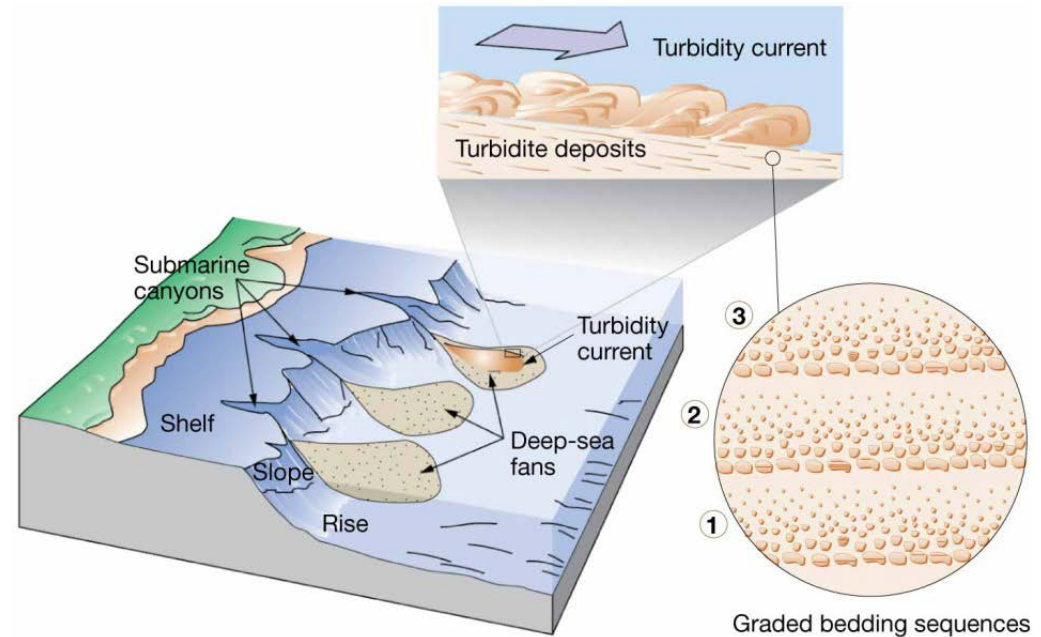
- Where deep ocean basins begin
- Topography similar to land mountain ranges
- Greater slope than continental shelf
  - Averages  $4^\circ$  but varies from  $1-25^\circ$  gradient
- Marked by **submarine canyons**

# 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**

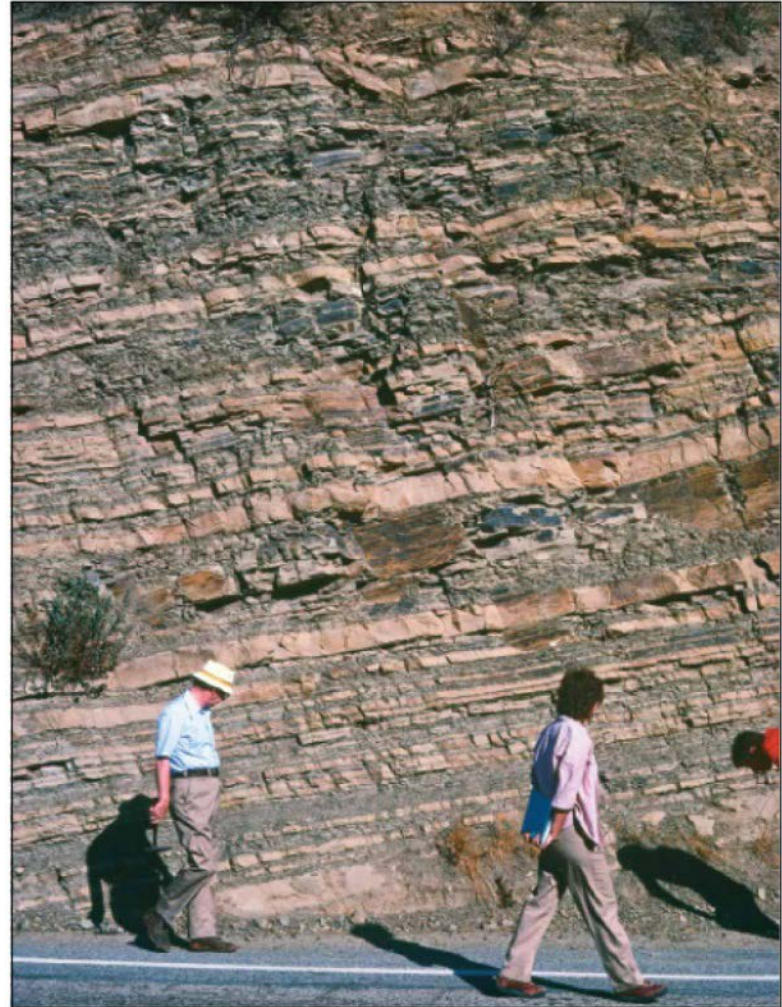
# Turbidity Currents

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



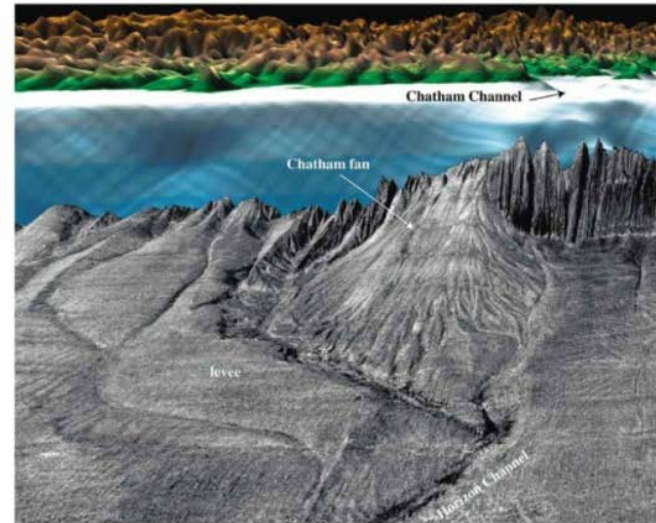
# Continental Rise

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



# Continental Rise

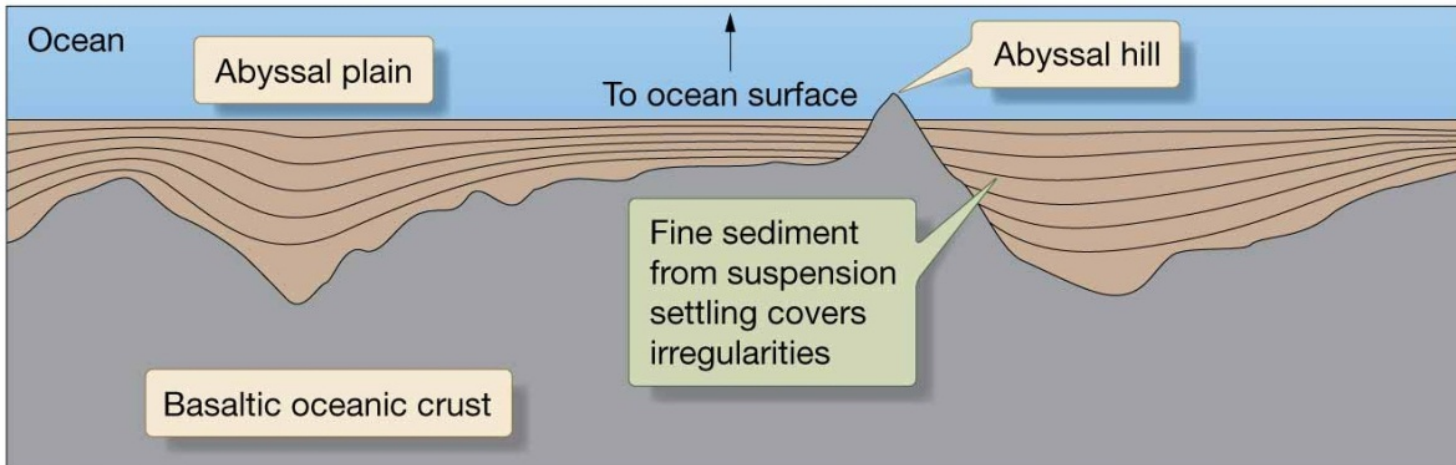
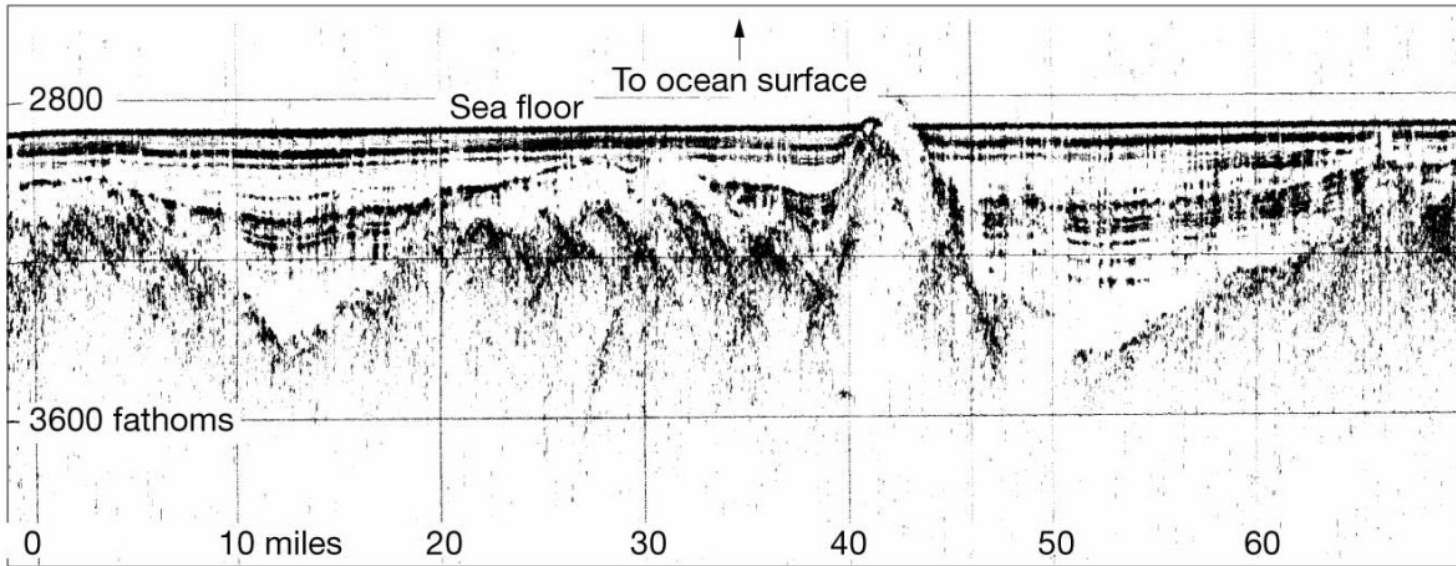
- Deposits generate **deep-sea fans**, or **submarine fans**
- Distal ends of submarine fans become flat abyssal plains



# Abysal 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



# 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**

# 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)

# Ocean Trenches

**Selected Pacific Ocean Trenches**

Name	Depth (km)	Width (km)	Length (km)
Middle America	6.7	40	2800
Aleutian	7.7	50	3700
Peru-Chile	8.0	100	5900
Kermadec-Tonga	10.0	50	2900
Kuril	10.5	120	2200
Mariana	11.0	70	2550

**Atlantic Ocean Trenches**

Name	Depth (km)	Width (km)	Length (km)
South Sandwich	8.4	90	1450
Puerto Rico	8.4	120	1550

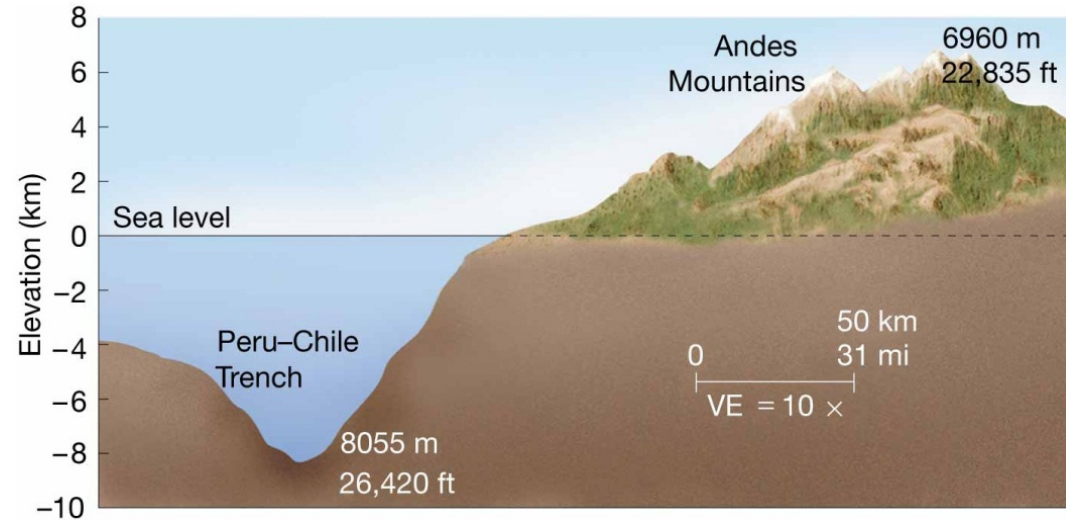


**Indian Ocean Trenches**

Name	Depth (km)	Width (km)	Length (km)
Java (Sunda)	7.5	80	4500

# Island and Continental Arcs

- **Volcanic arc** on nonsubducted ocean plate
- **Island arc**
  - Islands in ocean
  - Japan
- **Continental arc**
  - Mountains on land
  - Andes Mountains



# Pacific Ring of Fire

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

# Mid-Ocean Ridge

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

# Mid-Ocean Ridge

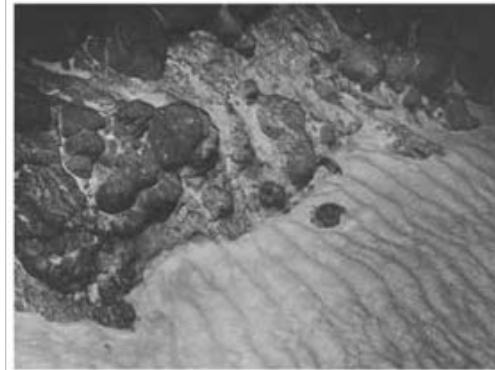
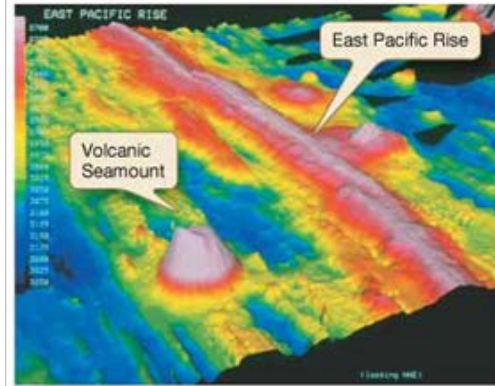


# Mid-Ocean Ridge Features

- **Rift Valley**
  - Downdropped area on crest of ridge
  - Marked by fissures and faults
  - Small earthquakes

# Mid-Ocean Ridge Features

- **Seamounts** – tall volcanoes
- **Pillow lava** or **pillow basalt** – shapes formed when hot basaltic lava quickly cools



# Mid-Ocean Ridge Features

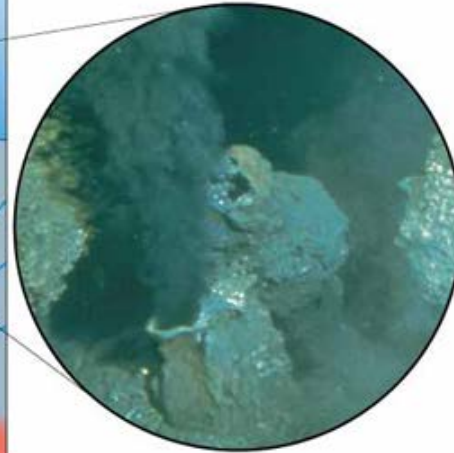
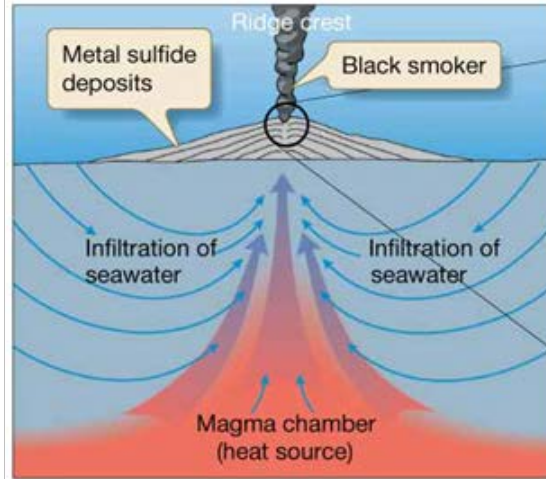
## Hydrothermal Vents

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

# 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)

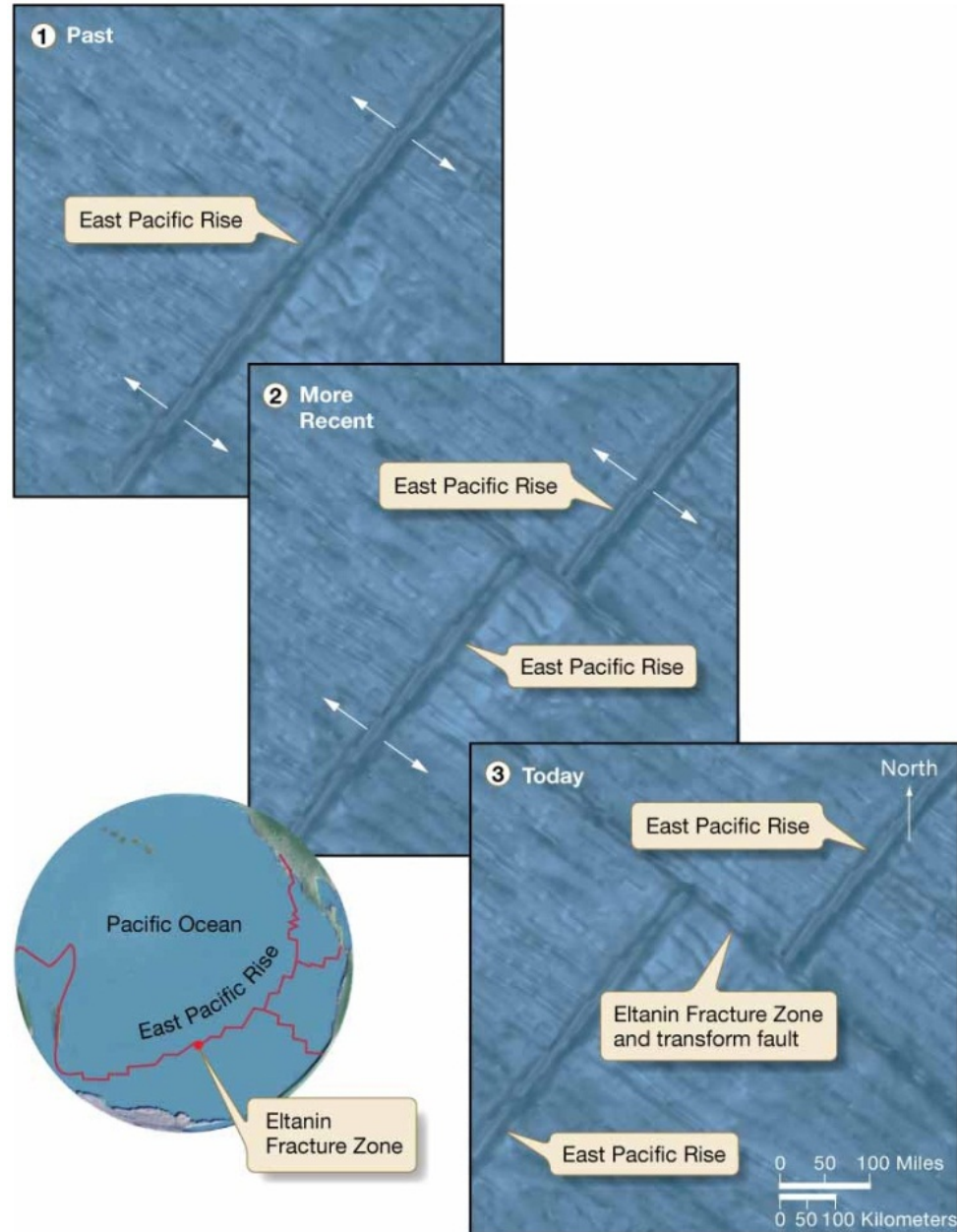
# Hydrothermal Vents



# 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

# Fracture Zones

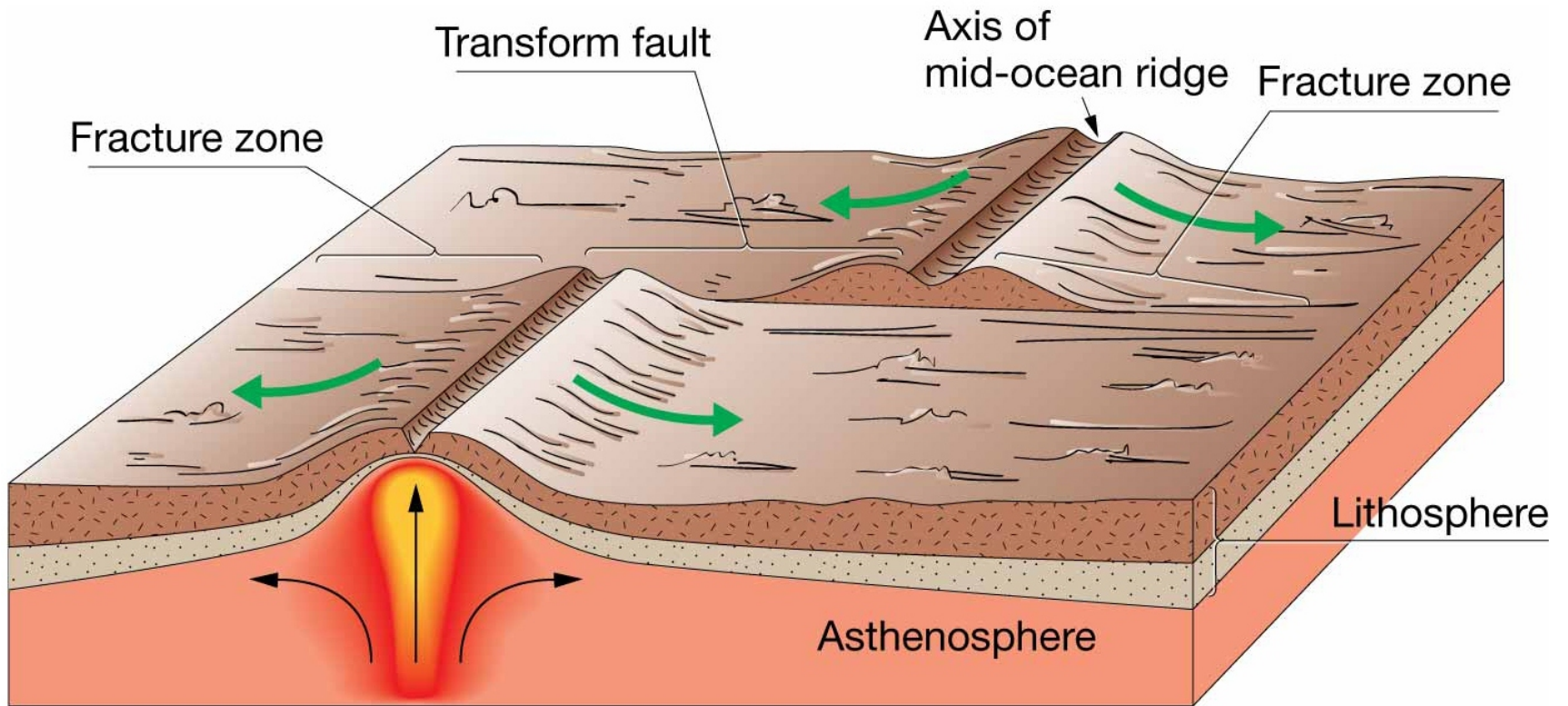


# Fracture Zones and Transform Faults

TABLE 3.1 COMPARISON BETWEEN TRANSFORM FAULTS AND FRACTURE ZONES

	Transform faults	Fracture zones
Plate boundary?	Yes—a transform plate boundary	No—an intraplate feature
Relative movement across feature	Movement in opposite directions	Movement in the same direction
		
Earthquakes?	Many	Few
Relationship to mid-ocean ridge	Occur <i>between</i> offset mid-ocean ridge segments	Occur <i>beyond</i> offset mid-ocean ridge segments
Geographic examples	San Andreas Fault, Alpine Fault, Dead Sea Fault	Mendocino Fracture Zone, Molokai Fracture Zone

# Fracture Zones and Transform Faults



# Oceanic Islands

- Volcanic activity
- Hotspots
- Island arcs
- Islands that are part of continents

# End of CHAPTER 3

## Marine Provinces