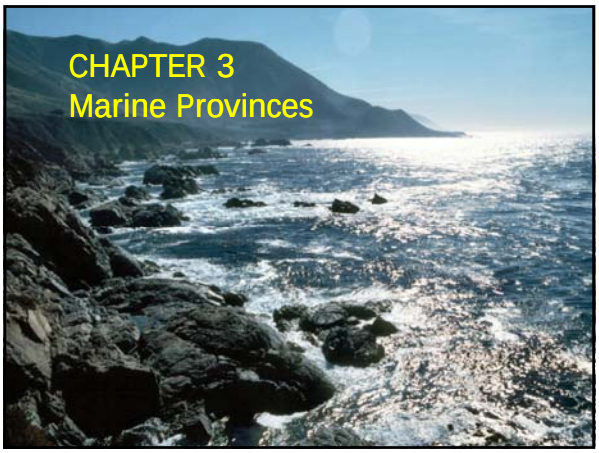



## Chapter Overview

- 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

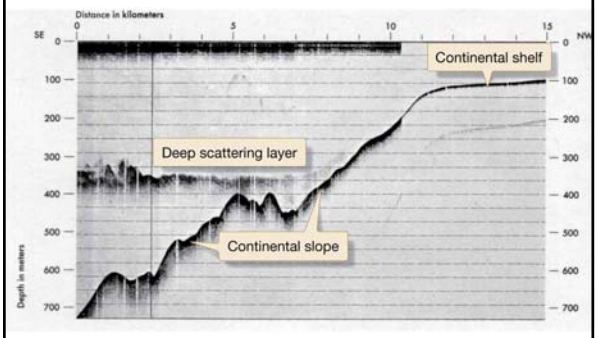
- *HMS Challenger*
  - Made first systematic measurements in 1872
- Deep ocean floor has relief
  - Variations in sea floor depth

## 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





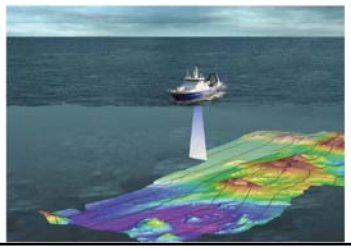

## Measuring Bathymetry

- 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

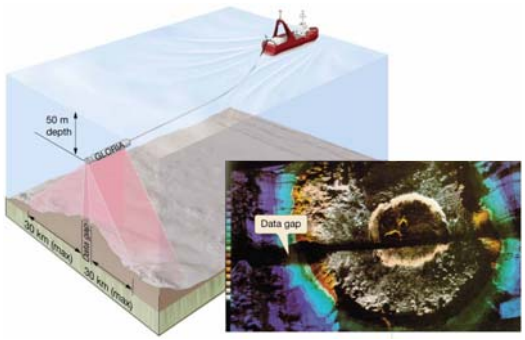
- SONAR
  - "SOund Navigation And Ranging" (acronym)



## 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

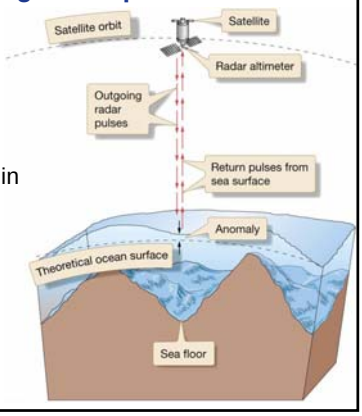
## GLORIA Side Scanning Sonar





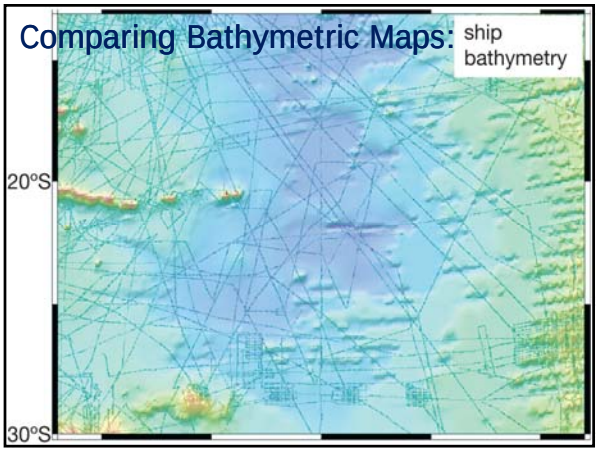

## Sea Floor Mapping from Space

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

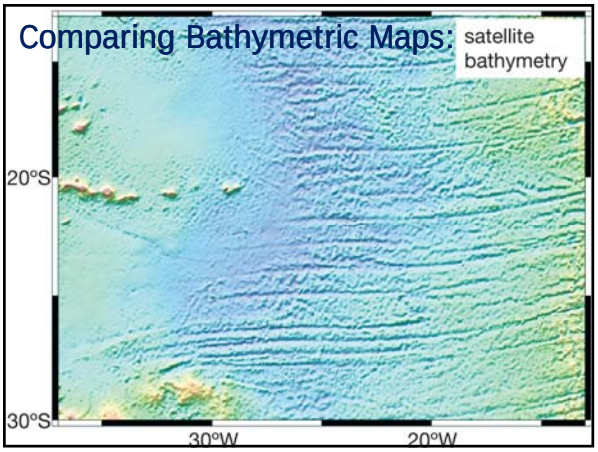





## Comparing Bathymetric Maps: ship bathymetry

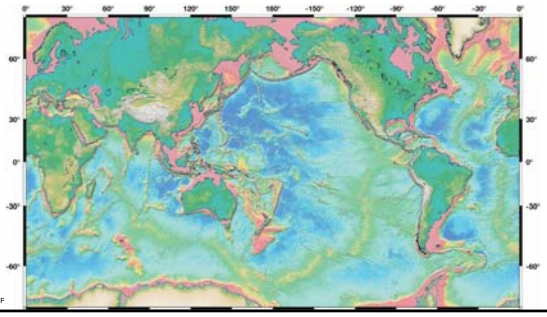



## Comparing Bathymetric Maps: satellite bathymetry




## Sea Floor Mapping from Space

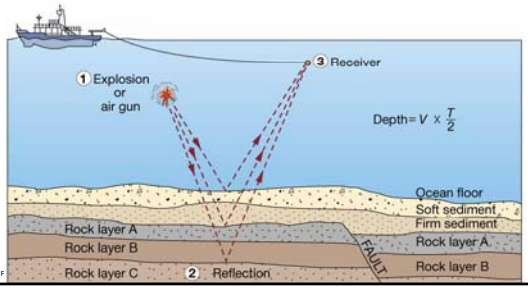
- Satellite-derived ocean surface gravity
- Reveals bathymetry where ships have not conducted research



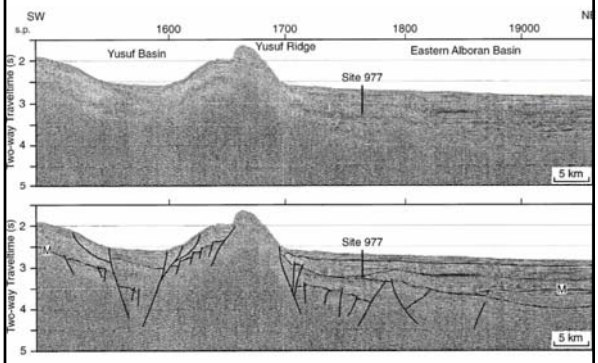


## Measuring Bathymetry

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



## Seismic Reflection Profile

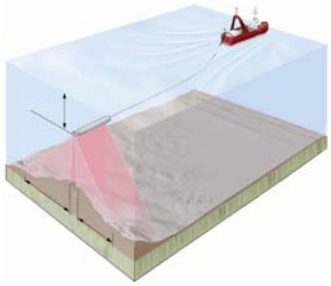



Site 977 refers to drilling site of JOIDES Resolution



## 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



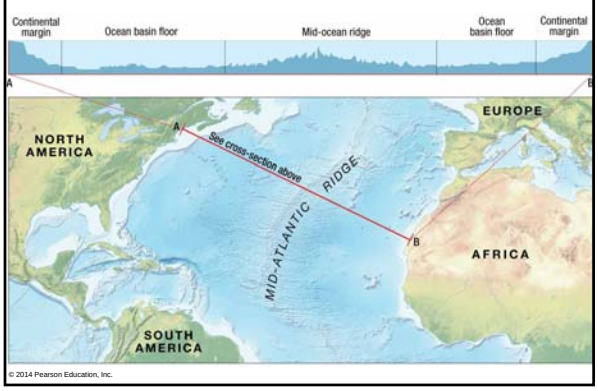
## Ocean Provinces

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

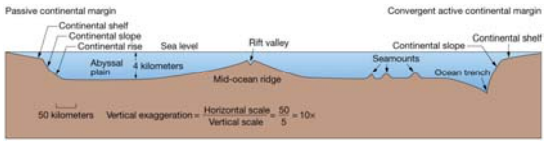





## Continental Margins

- 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

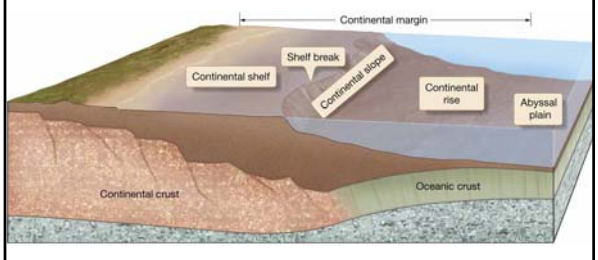


## Continental Margin Features

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



## Passive Continental Margin Features



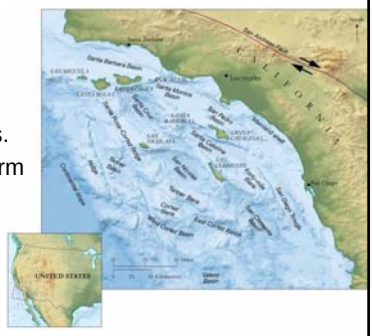



## Continental Shelf

- 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

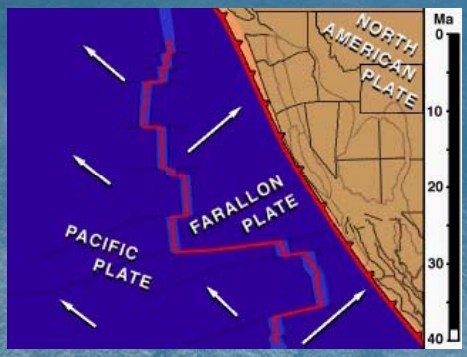
- Type of continental margin determines shelf features.
- Passive margins have wider shelves.
- California's transform active margin has a continental borderland.








## How the Continental Borderland came to be...




Animation downloaded from: *http://emvc.geol.ucsb.edu/*

## 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



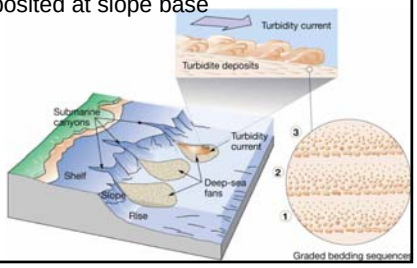
## Submarine Canyons

- 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

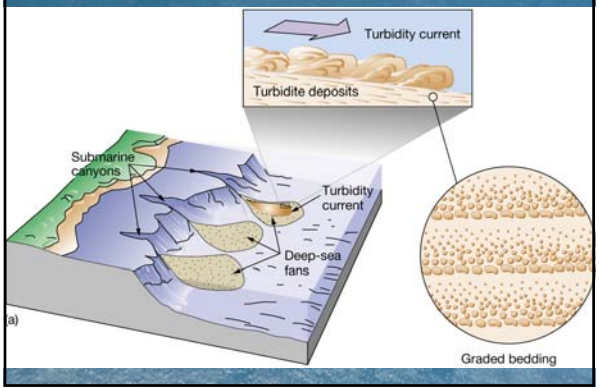


## Turbidity Currents

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



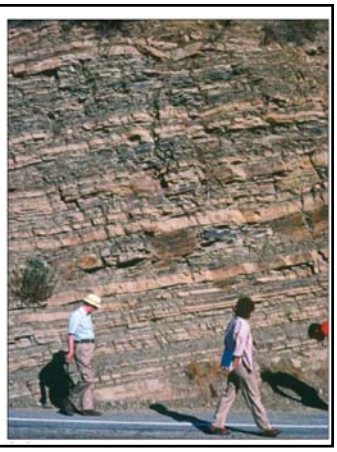
## Continental slope and submarine canyons




## LaJolla Submarine Canyon

## Continental Rise

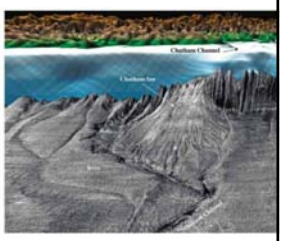
- Transition between continental crust and oceanic crust
- Marked by turbidite deposits from turbidity currents
- Graded bedding in turbidite deposits





## Continental Rise

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

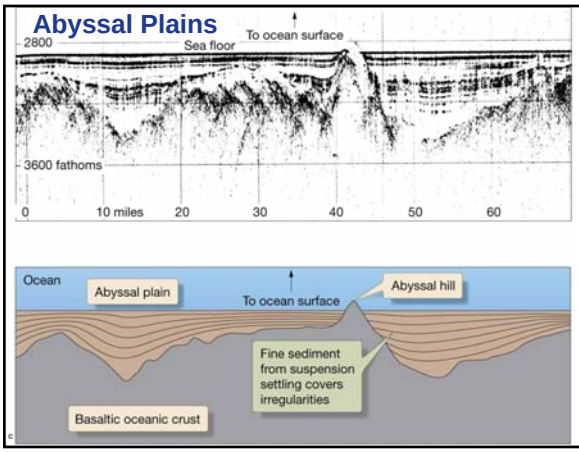


## Abyssal Plains

- 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



## 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

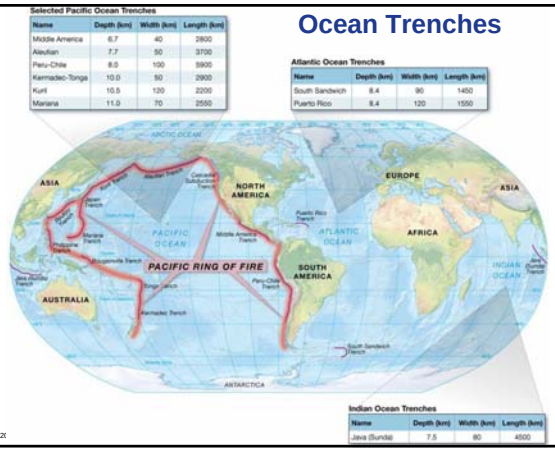


## Ocean Trenches and Volcanic Arcs

- Convergent margins generate ocean trenches.
  - Deepest part of oceans
  - Most in Pacific Ocean
  - Deepest trench – Mariana Trench at 11,022 meters (36,161 feet)



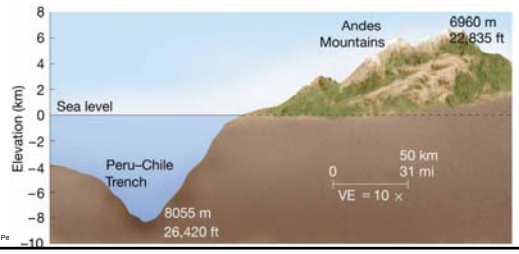
## Ocean Trenches






## Island and Continental Arcs

- Volcanic arc on non-subducted 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

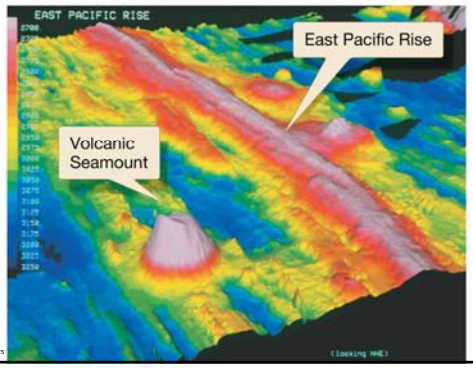

## Mid-Ocean Ridge Features

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



## Mid-Ocean Ridge Features

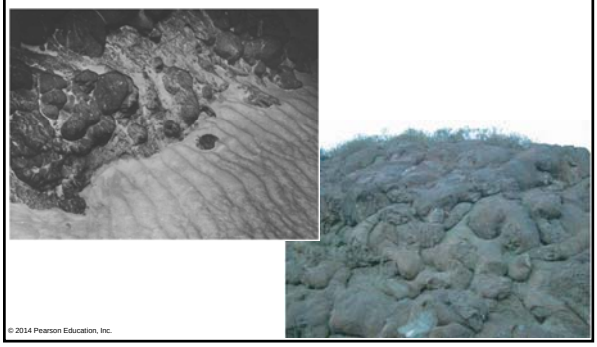
- Seamounts – tall volcanoes






## Mid-Ocean Ridge Features

- Pillow lava or pillow basalt
  - shapes formed when hot basaltic lava quickly cools





## Mid-Ocean Ridge Features

Hydrothermal Vents

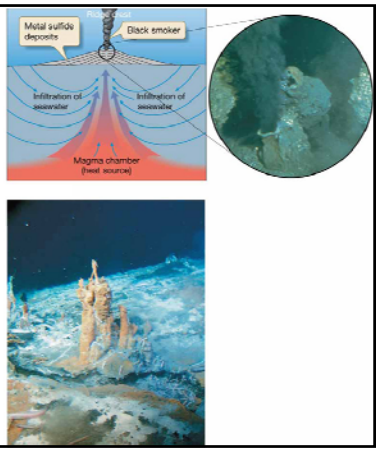
- Sea floor hot springs
- Foster unusual deep-ocean ecosystems able to survive without sunlight



## 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



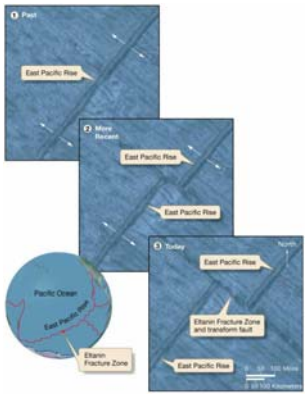



## Fracture Zones and Transform Faults

- 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





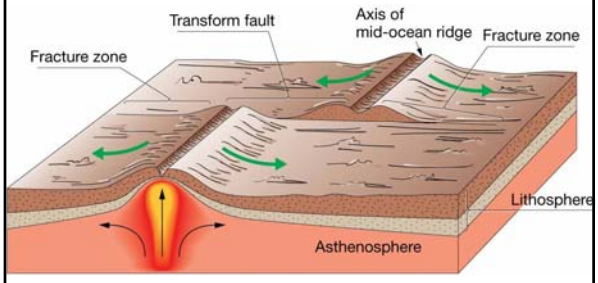

## Fracture Zones and Transform Faults

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 between offset mid-ocean ridge segments | Occur beyond offset mid-ocean ridge segments |
| Geographic examples | San Andreas Fault, Alpine Fault, Dead Sea Fault | Mendocino Fracture Zone, Molokai Fracture Zone |



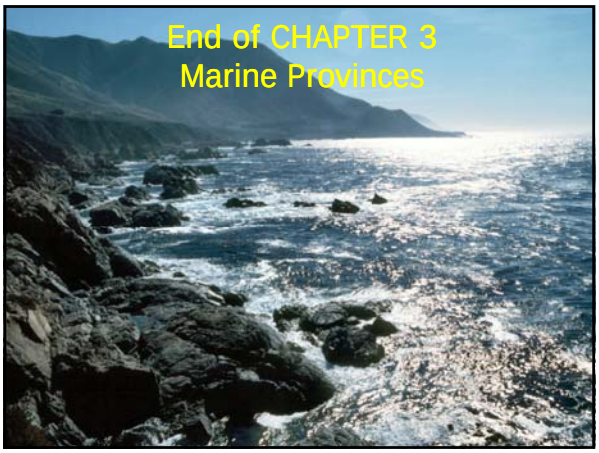
## Fracture Zones and Transform Faults






## Oceanic Islands

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


End of CHAPTER 3
Marine Provinces