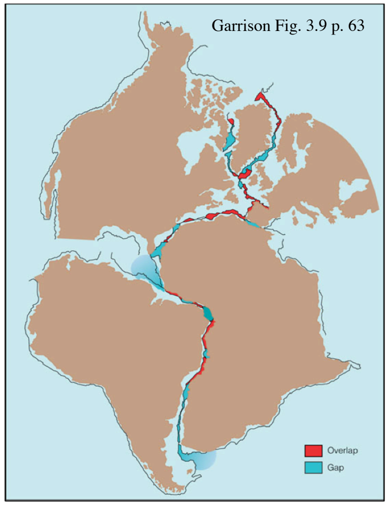
Additional Seafloor Evidence

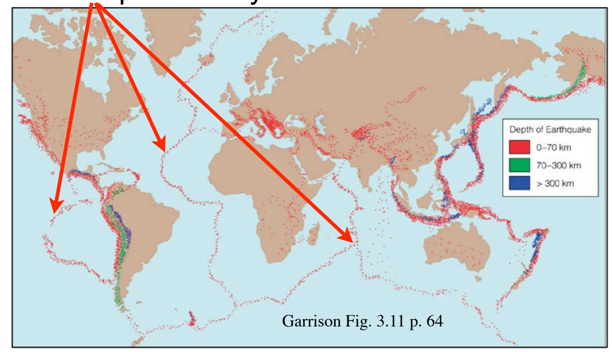
- Fit of continents
  - Earliest indication that crust maybe moving
    - Continental shelf breaks fit best
  - Observed for centuries
    - Alfred Wegener published theory of continental drift 1915



Garrison Fig. 3.9 p. 63

Additional Seafloor Evidence

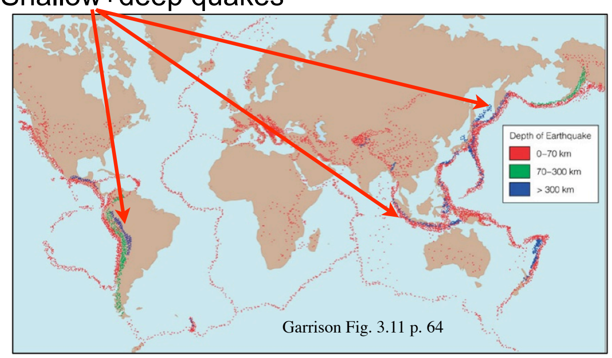
- Pattern of earthquakes
  - Closely traces mid-ocean ridges
    - Shallow quakes only



Garrison Fig. 3.11 p. 64

Additional Seafloor Evidence

- Pattern of earthquakes
  - Closely traces deep trenches
    - Shallow+deep quakes



Garrison Fig. 3.11 p. 64

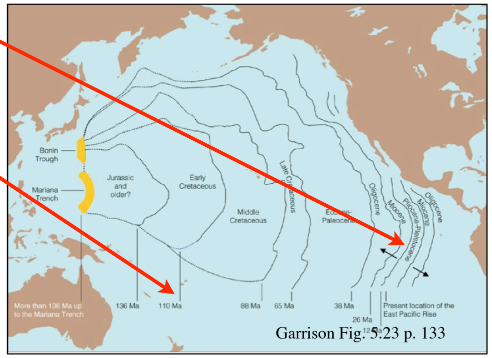
Additional Seafloor Evidence

- Pattern of earthquakes
  - Closely traces deep trenches
    - Quakes deeper farther from the mid-ocean ridge
      - Japan & Peru-Chile trenches
      - East Pacific Rise

Garrison Fig. 3.22 p. 73

Additional Seafloor Evidence

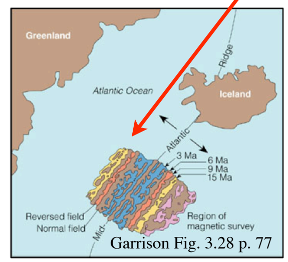
- Oldest sea floor “only” ~ 200 million years
  - Measured by decay of radioactive elements
  - Also depth of sediments
    - Youngest at rift valleys
    - Older with distance from rift
    - Oldest at ocean edges
      - Trench
      - Continental margin



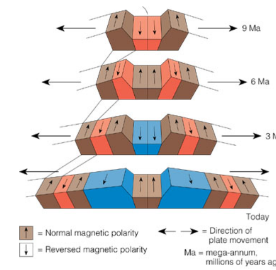
Garrison Fig. 5.23 p. 133

Additional Seafloor Evidence

- Magnetic patterns on sea floor
  - N & S poles reverse every few 100,000 years
  - Preserved as magma lithifies
    - “Stripes” of alternating polarity parallel to rift valley
    - Match known polar reversals recorded on land



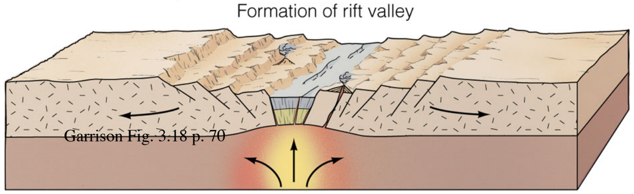
Garrison Fig. 3.28 p. 77



Sea-Floor Spreading

- New sea floor is being created
  - At the rift valleys
    - Sea floor is pulling apart to create valley
    - Shallow quakes
  - Driven by volcanic activity
    - Magma fills gap
    - Water & heat = hydrothermal vents

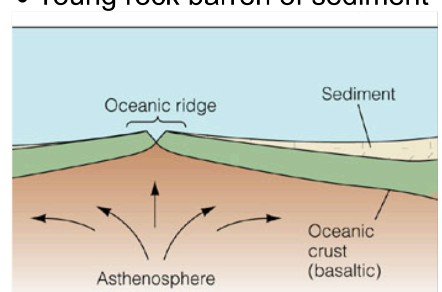
Formation of rift valley



Garrison Fig. 3.18 p. 70

Sea-Floor Spreading

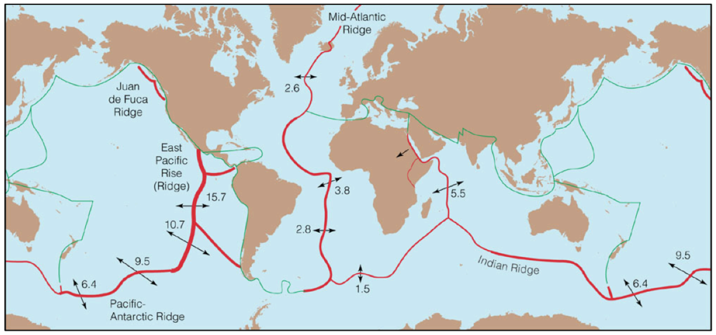
- New sea floor is being created
  - Mid-ocean ridge a broad elevated area
    - Raised by upwelling magma
    - And thermal expansion
    - Young rock barren of sediment



Garrison Fig. 4.8 p. 93

Sea-Floor Spreading

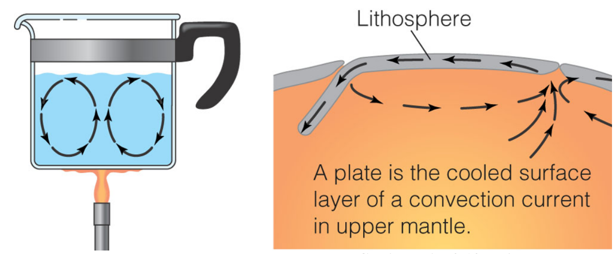
- Spreading rates vary around the oceans
  - Slow: steeper **ridges** (Mid-Atlantic)
  - Fast: more gradual **rises** (East Pacific)



Garrison Fig. 4.21 p. 100

Sea-Floor Spreading

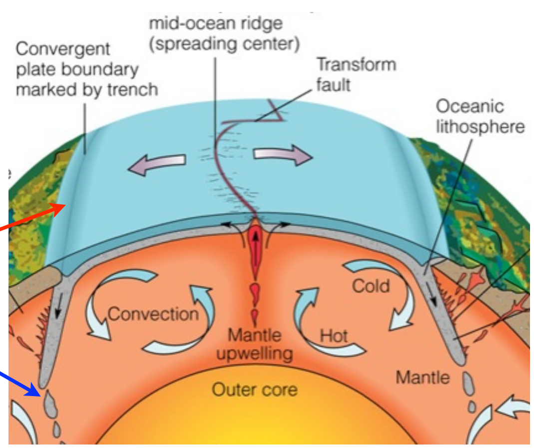
- Convection cells in the mantle
  - Driven by heat in Earth's interior
  - Lithosphere carried laterally away from rift
    - Solid crust + upper mantle
  - "Plastic" asthenosphere is the lubricant



Garrison Fig. 3.13 p. 67

Sea-Floor Spreading

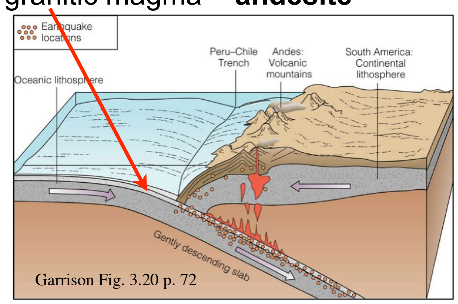
- Old sea floor is destroyed
  - Subduction beneath the surface
  - Forms trench
  - Returns to mantle & melts



Garrison Fig. 3.14 p. 67

Subduction Zone Volcanoes

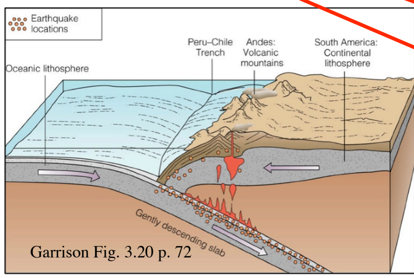
- Melting of subducting sea floor
  - Magma erupts at the surface
  - Creates chain of volcanoes parallel to trench
    - Mix of basaltic & granitic magma = **andesite**
    - Relatively cool
    - Higher silica = viscous
    - Steam from subducted wet sediments
    - Explosive stratovolcanoes



Garrison Fig. 3.20 p. 72

Subduction Zone Quakes

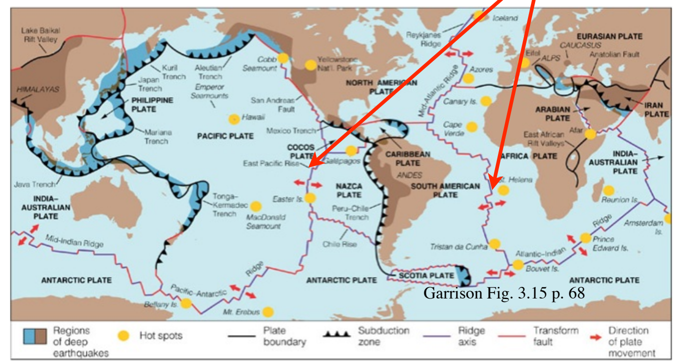
- Pattern of earthquakes
  - Closely traces deep trenches
    - Quakes deeper farther from the mid-ocean ridge
      - Peru-Chile trench
      - East Pacific Rise



Garrison Fig. 3.20 p. 72

Lithospheric Plates

- Like the cracked shell of an egg
  - Each plate created along one boundary by spreading: **Divergent (constructive) boundary**



Garrison Fig. 3.15 p. 68

Lithospheric Plates

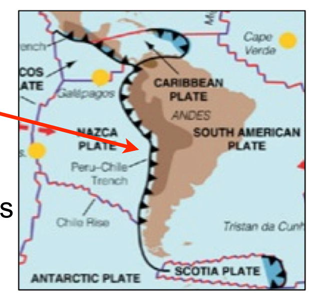
- Fate at opposite boundary varies
  - Subduction zone = **Convergent (destructive)**
    - One of converging plates subducts

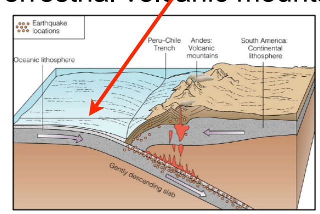
Garrison Fig. 3.15 p. 68

3 Types of Subduction Zones

- Ocean-continent
  - Oceanic crust is subducted
    - Because it is more dense
    - E.g. oceanic Nazca plate beneath continental S. American plate
    - Terrestrial volcanic mountains

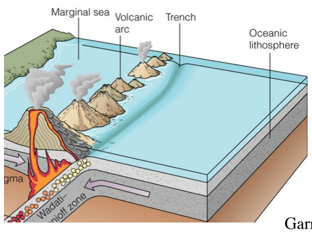
Garrison Fig. 3.15 p. 68

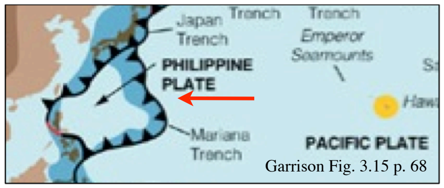



Garrison Fig. 3.20 p. 72

3 Types of Subduction Zones

- Ocean-ocean
  - Older oceanic crust is subducted
    - Because it is more dense & heavier sediment load
    - Deeper isostatic sinking
  - E.g. Pacific plate beneath Phillippine plate
    - Volcanic seamount chain



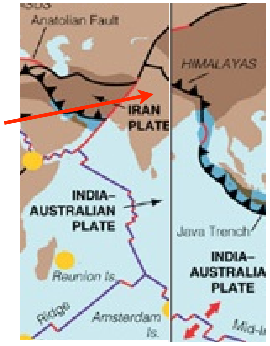


Garrison Fig. 3.15 p. 68

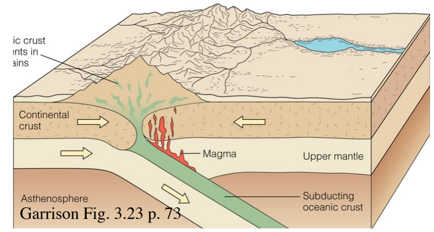
Garrison Fig. 3.22a p. 73

3 Types of Subduction Zones

- Continent-Continent
  - Closing of an ocean
    - E.g. India colliding with Eurasia
  - Non-volcanic mountain range (Himalayas)
    - 2 plates equal density



Garrison Fig. 3.15 p. 68

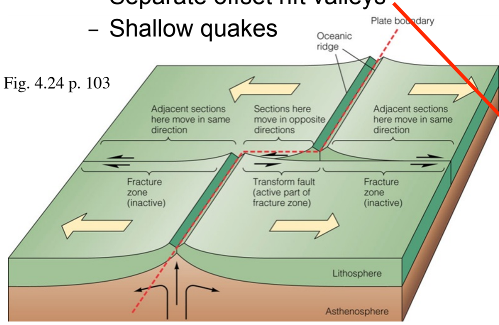


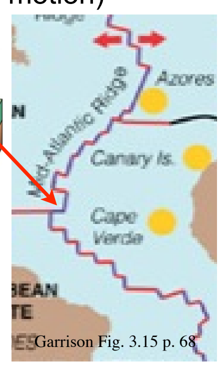
Garrison Fig. 3.23 p. 73

A 3rd Type of Plate Boundary

- **Transform** or **conservative**
  - Plates are neither created nor destroyed
    - Slide past each other ("strike-slip" motion)
      - Separate offset rift valleys
      - Shallow quakes

Garrison Fig. 4.24 p. 103

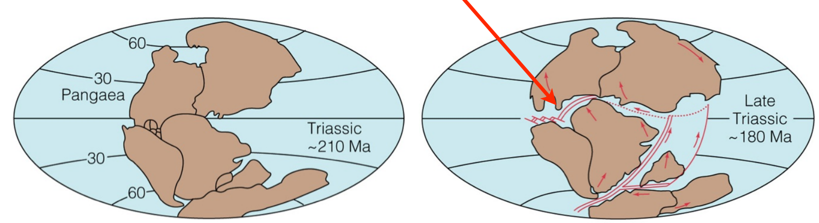




Garrison Fig. 3.15 p. 68

History of the Plates

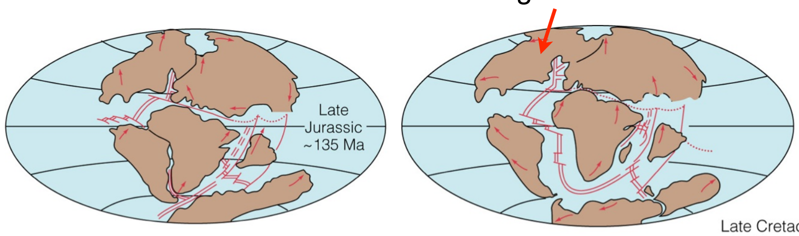
- Wegener's idea of Pangaea
  - All continents once joined
  - Began breaking up ~200 million years ago
    - Opening of rift valleys



Garrison Fig. 3.19 p. 71

History of the Plates

- "Panthalassa" = "All seas"
  - What is now the Pacific = oldest ocean
  - Formation of the younger Indian & Atlantic
    - Mid-Atlantic & Mid-Indian Ridges form
    - N. & S. America start moving westward

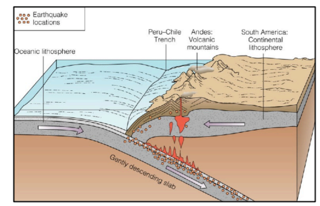


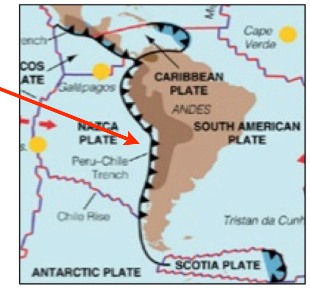
Late Cretaceous ~65 Ma

Garrison Fig. 3.19 p. 71

2 Types of Margins

- Active (leading) margin = Subduction zone
  - On a convergent plate boundary
    - A trench, not a rise
    - Narrow, steep, seismically active
    - Generally less sediment

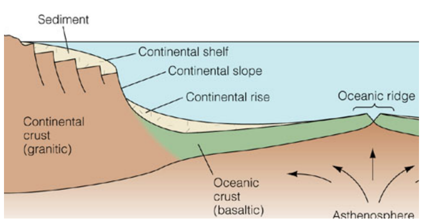




Garrison Fig. 3.15 p. 68

2 Types of Margins

- Passive (trailing) margin
  - Not on a plate boundary; in mid-plate
  - Where the continent split in two
    - Continental rise
    - Wide, gradual, seismically inactive, more sediment

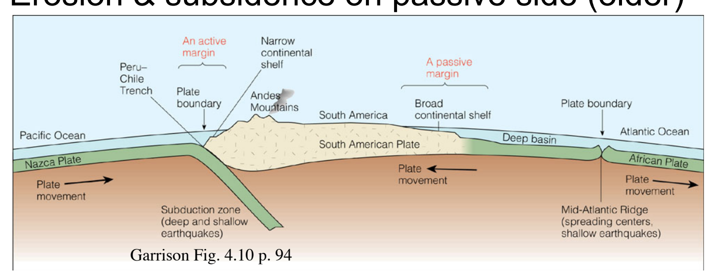


Garrison Fig. 4.8 p. 93

Garrison Fig. 3.15 p. 68

2 Types of Margins

- Are you on an active or passive margin?
  - Are you leading or trailing?
  - Mountain building & volcanoes on the active side (younger)
  - Erosion & subsidence on passive side (older)



Garrison Fig. 4.10 p. 94

“Hot Spot” Volcanoes

- Isolated deep magma sources in mid-plate
  - Pure basalt magma
    - Less silica & gas
    - More fluid & less explosive
  - Hawaii the classic
    - Rivers of lava

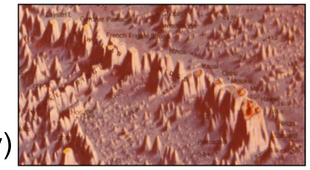
http://theorie.physik.uni-wuerzburg.de/~hesselb/hawaii/

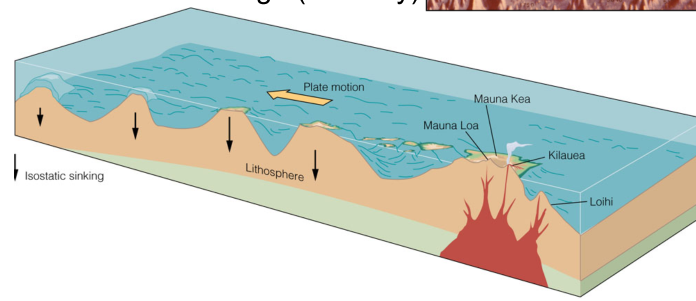
www.terragalleria.com/pictures-subjects/outside/picture.outside.havo3705.html

“Hot Spot” Volcanoes

Garrison Fig. 3.32 p. 81

- Plate moves over stationary magma plume
  - Creates chain of volcanoes
    - Trend in age, height, activity
    - Peaks depress lithosphere
    - Peaks sink with age (isostasy)





Summary

- Sediment cores
  - Layers & thickness of sediment at a given location give clues to age of sea floor & changes in ocean conditions over time