Chapter Two

The Sea Floor

Geography of the Ocean Basins

- The world ocean is the predominant feature on the Earth in total area.
- In the Northern Hemisphere, 61% of the total area is ocean.
- In the Southern Hemisphere, about 80% of the total area is ocean.
- The world ocean is divided into four large basins: Pacific, Atlantic, Indian and Arctic.

Structure of the Earth

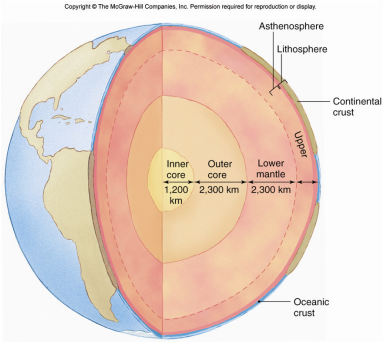
- The Earth is thought to have originated 4.5 billion years ago from dust accumulated from the Big Bang
- Due to heat associated with these events, the early Earth was likely molten
- This allowed materials to settle by density as the materials cooled

Structure of the Earth

- Heavier materials settled deep in the Earth
- Lighter components formed a thin crust
- Eventually, the Earth's oceans and atmosphere began to form
- Earth's location relative to the sun allows for water to stay liquid – an essential element to sustain life

Internal Structure of the Earth

- Core – innermost layer; solid inner core and liquid outer core; iron-rich.
- Mantle – middle layer; semi-plastic composition.
- Crust – outermost layer; thinnest portion of the Earth.



Continental versus Oceanic Crust

- Oceanic crust – made up of dark-colored mineral, basalt; denser than continental crust; younger than continental crust (less than 200 million years old).
- Continental crust – light-colored granite construction mainly; less dense; some crust as old as 3.8 billion years old.

Continental Drift

- Proposed in 1912 by Alfred Wegner
- He suggested that all continents had been joined in a single supercontinent which he named Pangaea.
- He proposed that Pangaea began breaking up 180 million years ago.
- At the time, his proposal was not widely accepted; he could not explain HOW this occurred.

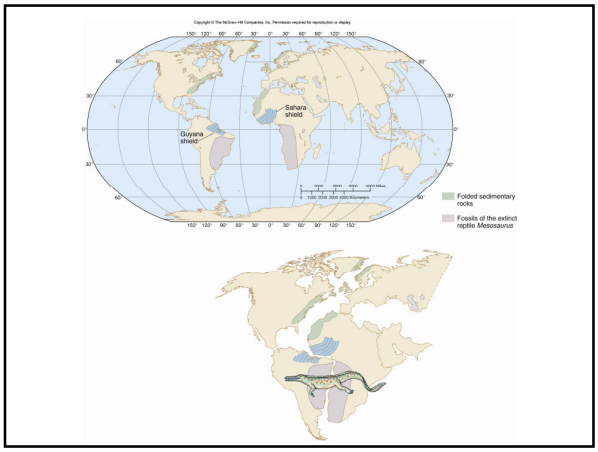
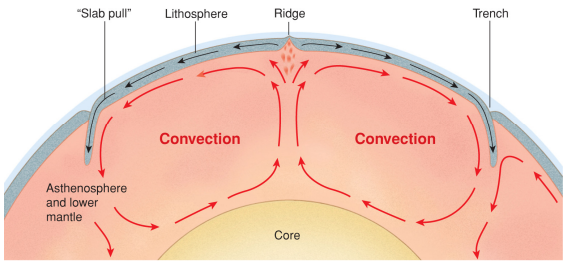


Plate Tectonics

- Plate tectonics explains the "HOW" behind Wegner's continental drift theory
- The main features of plate tectonics are:
  - The Earth's surface is covered by a series of crustal plates
  - The ocean floors are constantly moving; spreading in the center and sinking at the edges and being regenerated.
  - Convection currents beneath the plates assist movement
  - Heat from the mantle drives these currents

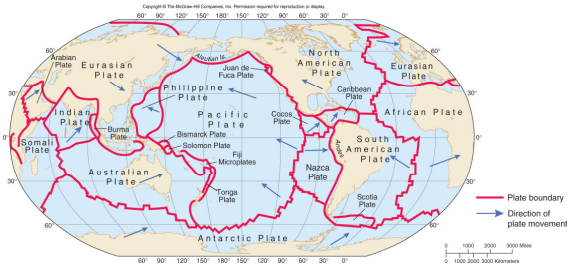
Figure 02_15



Evidence for Plate Tectonics

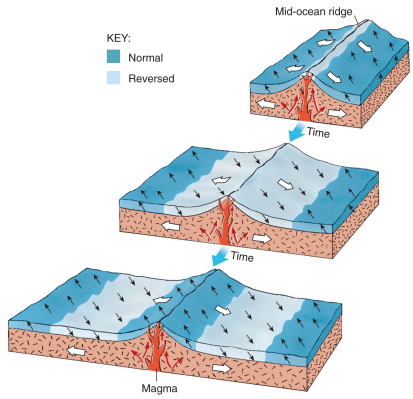
- Mid-Oceanic Ridges
  - The mid-oceanic ridges rise from ocean floor – a chain of submarine volcanic mountains
  - at regular intervals, the ridge is displaced by faults in the Earth's crust called transform faults
  - Very little sediment is located at the bottom near these ridges; sediment gets thicker away from the ridges signifying that the crust further from the ridge is older (sediment has had time to accumulate)

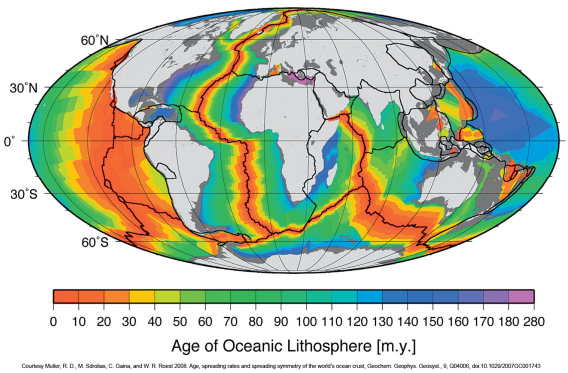
Figure 02_11



Evidence for Plate Tectonics

- Geomagnetic Anomalies:
  - Occasionally, at random intervals, the Earth's magnetic field reverses. New rock formed from magma records the orientation of Earth's magnetic field at the time the magma cools.
  - Studies of the sea floor revealed "stripes" of alternating magnetization parallel to the mid-oceanic ridges. This is evidence for continuous formation of new rock at these ridges. As new rock forms, older rock is pushed farther away from the ridge, producing these patterns in the rock.





Courtesy Muller, R. D., M. Sdrolias, C. Gaina, and W. R. Roest 2008. Age, spreading rates and spreading symmetry of the world's ocean crust, Geochem. Geophys. Geosyst., 9, Q04006, doi:10.1029/2007GC001743

Evidence of Plate Tectonics

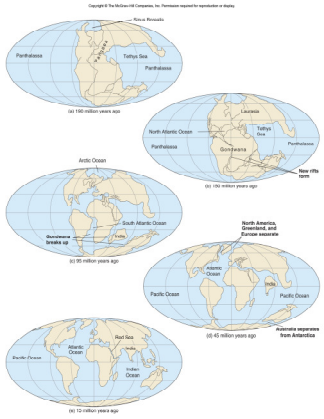
- **Island Arcs**
  - Chains of islands are found throughout the oceans, especially in the western Pacific.
  - These "Island arcs" are usually situated along deep sea trenches on the continental side of trenches.
  - These observations, along with many other studies of our planet, support the theory that underneath the Earth's crust is a layer of heated rock driving the creation of new ocean floor.

Geologic History

- Pangaea was surrounded by a single world ocean, Panthalassa
- Inland Pangaea was likely a hostile desert environment
- The Tethys Sea separated Eurasia from Africa
- These were in place about 200 million years ago

Geologic History

- About 180 million years ago, a rift began to form between North America and the combined continents of South America/Africa
- This rift separated Pangaea into two large continents, Laurasia and Gondwana
- This rift was the beginning on the Mid-Atlantic Ridge



Geologic History

- Also around 180 million years ago, a rift began to split up Gondwana and the early Indian Ocean began to form
- About 135 million years ago, a rift between South America and Africa began to form
- This rift joined the mid-ocean ridge in the North Atlantic to form a single mid-Atlantic ridge

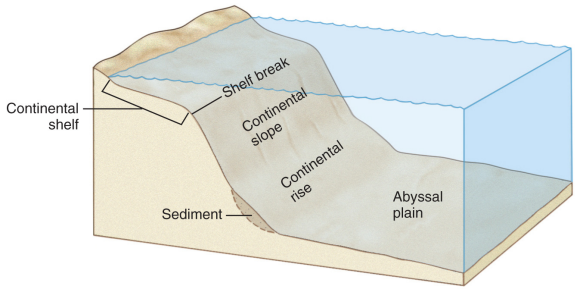
Geologic History

- As the Atlantic Ocean grew (grows), the Americas were (are) carried farther from Eurasia and Africa
- The Atlantic Ocean to continues to grow and the Pacific Ocean continues to shrink

Continental Margins

- The margins of continents are boundaries between continental crust and oceanic crust
- They generally consist of:
  - Continental shelf (most landward)
  - Continental slope
  - Continental rise (most seaward)

Figure 02_19



The Continental Shelf

- Increased dramatically with formation of present day continents
- Makes up about 8% of the ocean's surface area
- However, it is biologically the richest area of the ocean
- The width varies from 1 km (0.6 mi) to 750 km (470 mi)
- Shelf ends at shelf break which occurs at a depth of 120 – 400 m (9400-1300 ft)

Continental Slope

- Can be thought of as the "edge" of a continent
- Begins at the shelf break and continues to deep sea floor
- Much steeper than continental shelf and continental rise

Continental Rise

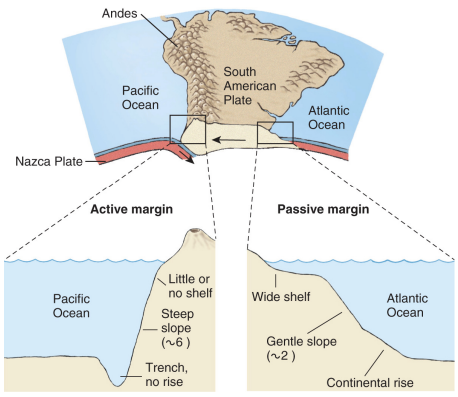
- Formed by sediments that have been pushed down from continental shelf and slope
- It can be thought of as an underwater river delta (the river in this case is formed of sediments)

Types of Margins

- Passive margins:
  - Relatively inactive geologically
  - Characterized by flat, wide coastal plains, wide continental shelves and gradually sloping continental slopes
  - Example: East Coast of US

Types of Margins

- Active Margins:
  - Sites of more intense geologic activity including earthquakes, volcanoes and trenches
  - Characterized by steep, rocky shorelines, narrow continental shelves and steep continental slopes
  - Example: West Coast of US



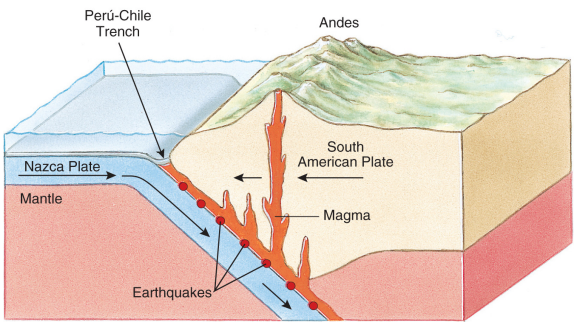
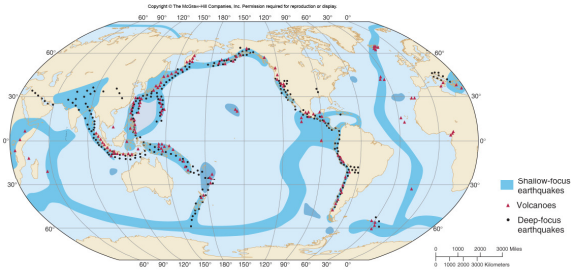
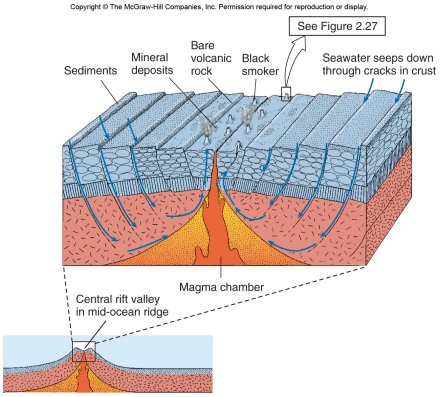
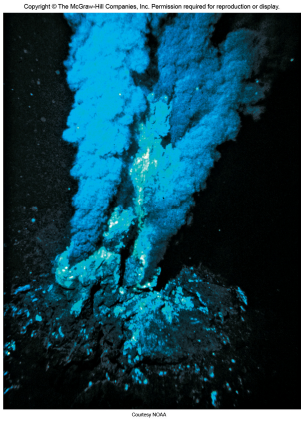


Figure 02_08

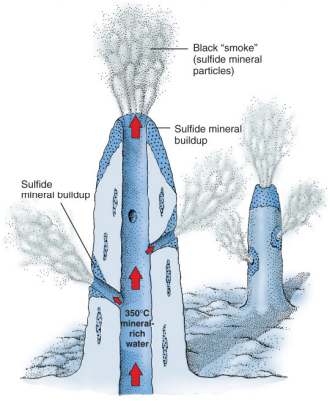


Deep sea vents

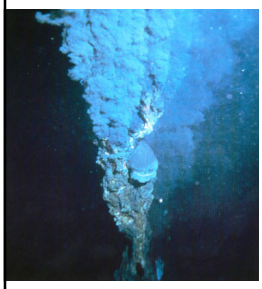


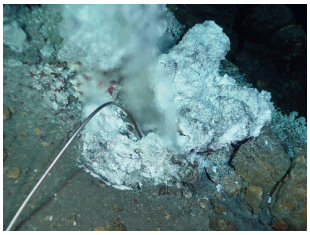


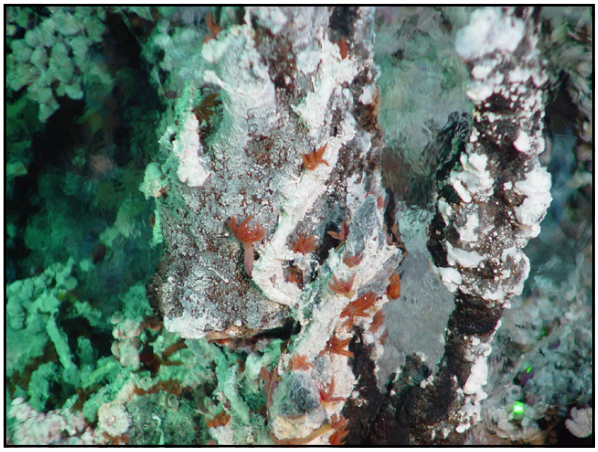
Courtesy NOAA

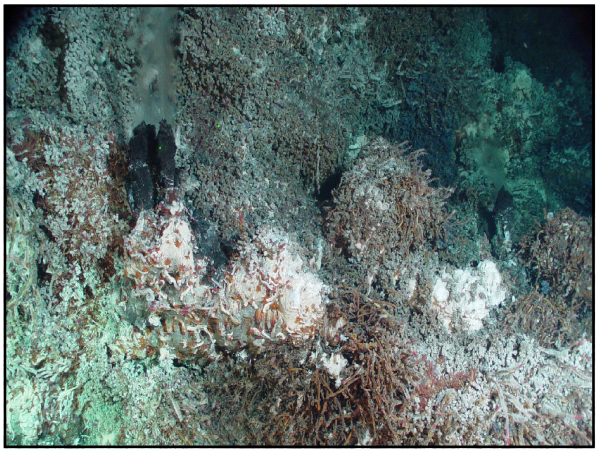


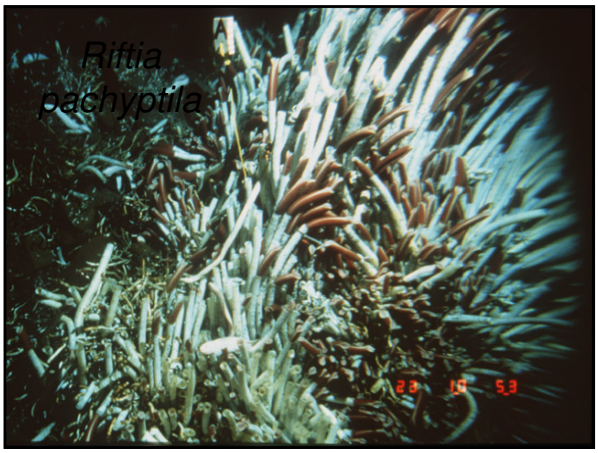
Deep sea hydrothermal vents

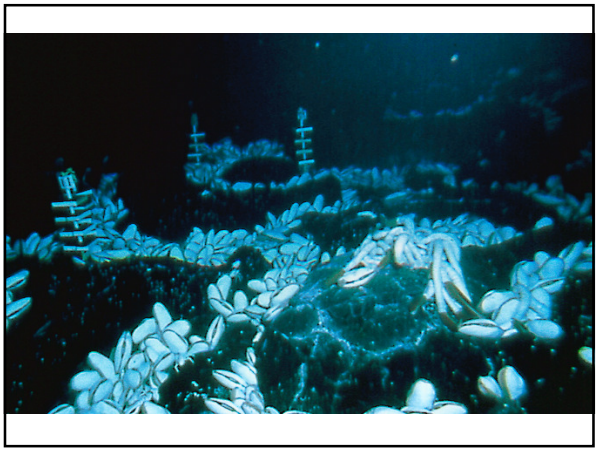






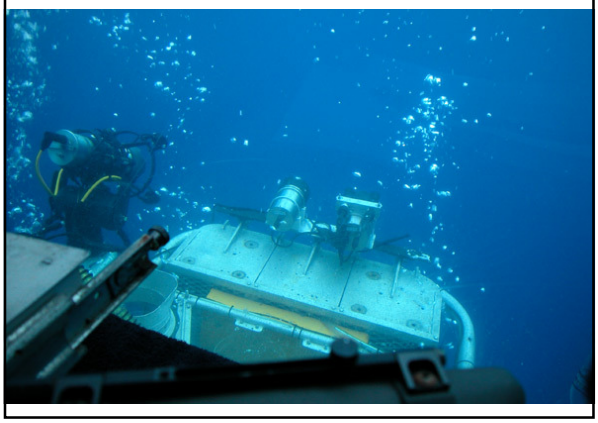


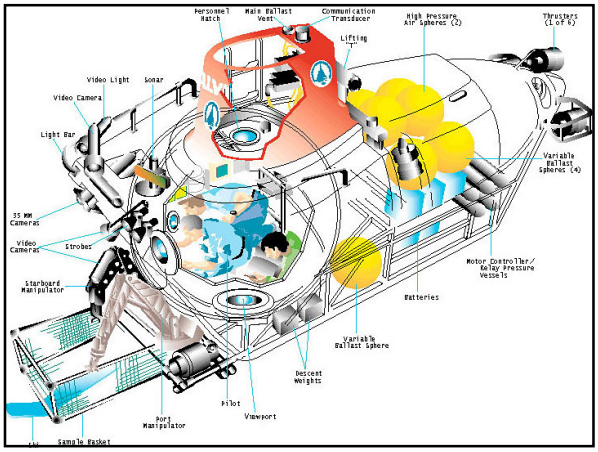




Alvin

- Location: Mass. , USA
- Depth Rating: 4450 meters
- Year of Mfg: 1964
- Occupants: 3



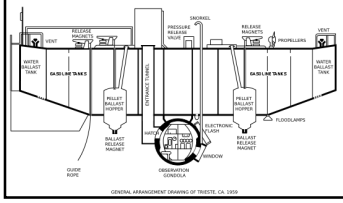


Barton and Beebe - Bathysphere

- 1930, they piloted the first manned dive of 245 m
- 1934 to 923 m the record remaining unbroken for 15 years.

Trieste

- 10,900 m, Challenger Deep, Mariana Trench 1960



GENERAL ARRANGEMENT DRAWING OF TRIESTE, CA. 1959

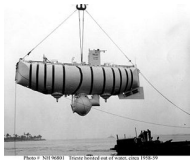


Photo # NH 96861 Trieste hoisted out of water, circa 1958-59

Nautile

- Location: FRANCE
- Depth Rating: 6000 meters
- Year of Mfg: 1985

- Occupants: 3

Johnson SeaLink 1/2

- Location: Florida , USA
- Depth Rating: 800 meters

- Year of Mfg: 1971 / 1975

Shinkai 6500

- Location: Tokyo,Japan
- Depth Rating: 6500 meters
- Year of Mfg: 1987
- Occupants: 3

Chinese submersible

- 7000 meter depth
- Still in testing

Remote operated vehicle Jason

- Maximum depth 6500 m

ABE autonomous benthic explorer

ABE seafloor mapping

Neptune Canada