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SIXTH EDITION

Invitation to Oceanography

Chapter 2

The Planet Oceanus

Composition of the Earth

- The Earth consists of a series of concentric layers or **spheres** which differ in chemistry and physical properties.
- There are two different ways to describe those layers: **Composition** and **Physical State**
- The **compositional** layers of the Earth are:
  - the Crust
  - the Mantle
  - the Core
    - The Core is subdivided into a molten outer core and solid inner core

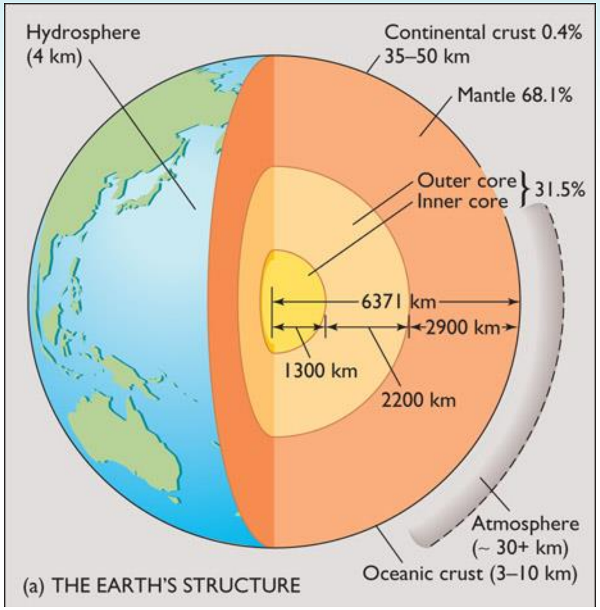

Figure 02.01a: The Earth's internal mass. An outer crust, a middle mantle, and a center core (solid inner core surrounded by molten outer core).

The Effects of Pressure and Temperature

- Increasing pressure **raises** the melting point of a material by forcing atoms and molecules into tighter configurations, and holding them together more strongly.

- Increasing temperature provides additional energy to the atoms and molecules of matter.

- This allows them to move farther apart, eventually causing the material to melt.

Pressure and Temperature (continued)

- Both pressure and temperature increase toward the center of the Earth, but at variable rates.

- Divisions of the Earth based upon **physical state** are:
  - the Lithosphere
  - the Asthenosphere
  - the Mesosphere
  - the Outer core
  - the Inner core

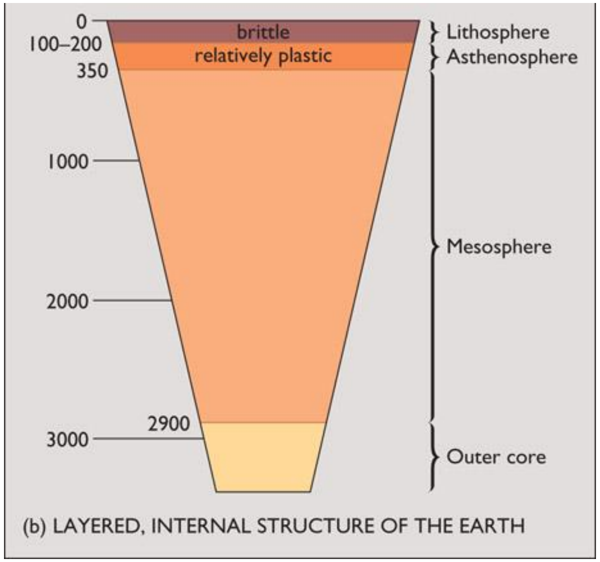

Figure 02.01b: The Earth's interior

Three spheres surround the rocky portion of the Earth

- **Hydrosphere** includes all of the "free" water of the Earth contained in:
  - Oceans
  - Lakes
  - Rivers
  - Snow
  - Ice
  - Water vapor
  - Groundwater

The Earth's Spheres (continued)

- **Atmosphere** is the gaseous envelope that surrounds the Earth .
  - It is mainly a mixture of nitrogen and oxygen.

- **Biosphere** refers to all living and non-living organic matter.

The Sea Floor

- **Physiography** and **bathymetry** (the topography of the submarine landscape) allow the sea floor to be subdivided into three distinct provinces:
  - continental margins
  - deep ocean basins
  - mid-oceanic ridges

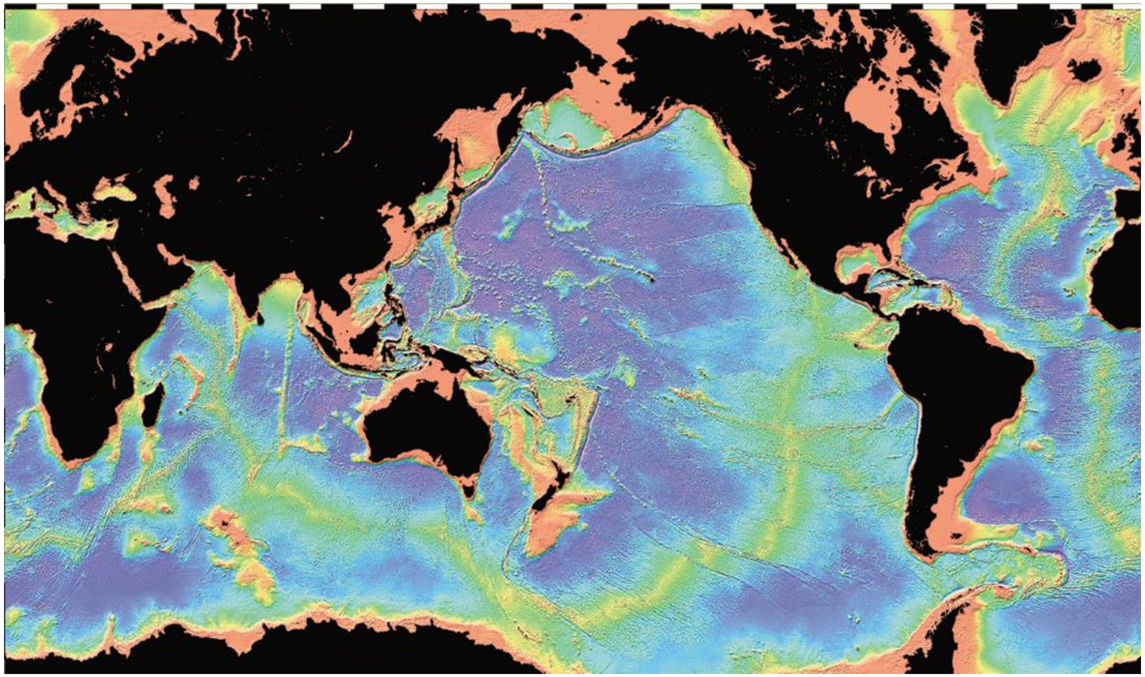

Figure 02.02: This map shows the major bathymetric features of the ocean basins of the Pacific Ocean, the Atlantic Ocean, and the Indian Ocean.

Courtesy of NOAA

- **Continental margins** are the submerged edges of the continents.
- They consist of massive wedges of sediment eroded from the land and deposited along the continental edge.
- The continental margin can be divided into three parts:
  - the Continental shelf
  - the Continental slope
  - the Continental rise

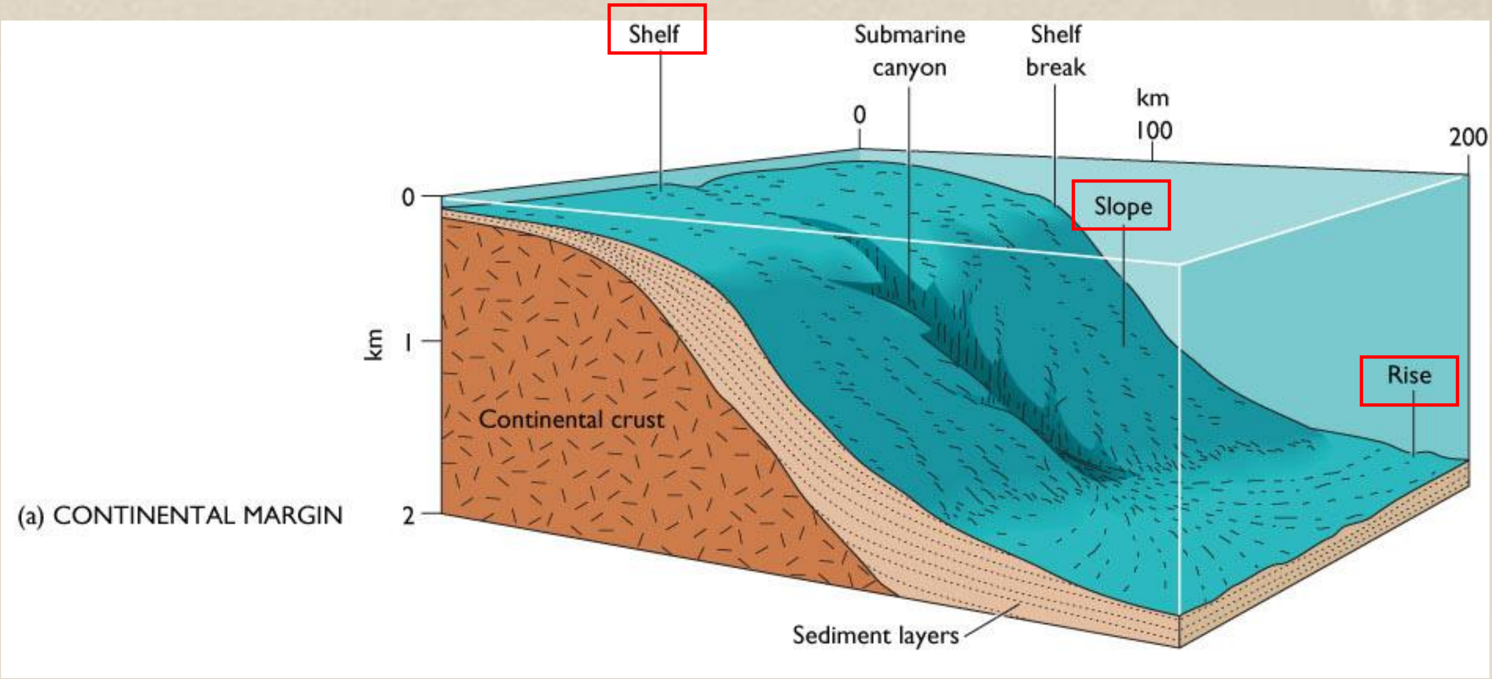

Figure 2-3a Continental Margin

2-2 The Physiography of the Ocean Floor

The Sea Floor (Continued)

- The **Deep Ocean Province** lies between the continental margins and the mid-oceanic ridges.

- It includes a variety of features from mountainous to flat plains:
  - Abyssal plains
  - Abyssal hills
  - Seamounts
  - Deep sea trenches

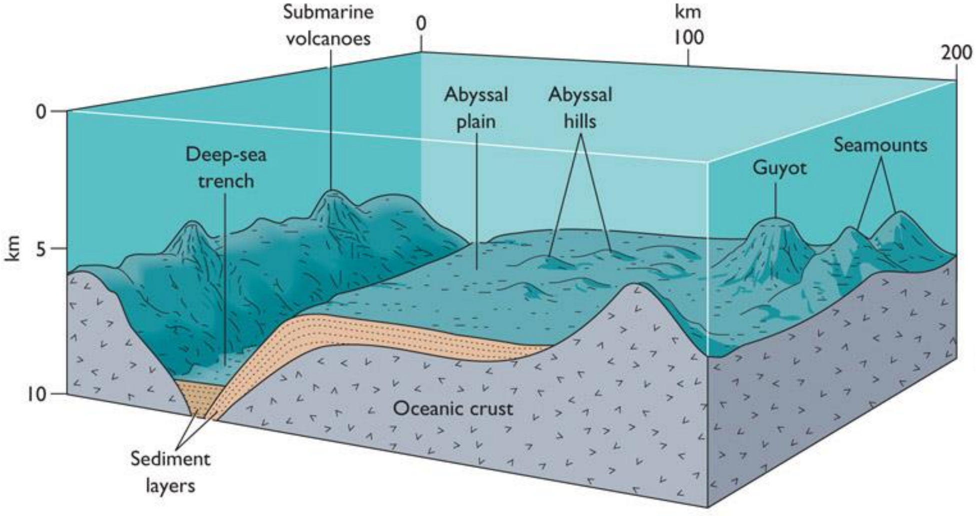

Figure 02.03b: The floor of the deep-ocean basin.

- **Midoceanic Ridge Province** consists of a continuous submarine mountain range.
- It covers about one third of the ocean floor.
- It extends for about 60,000 km around the Earth.

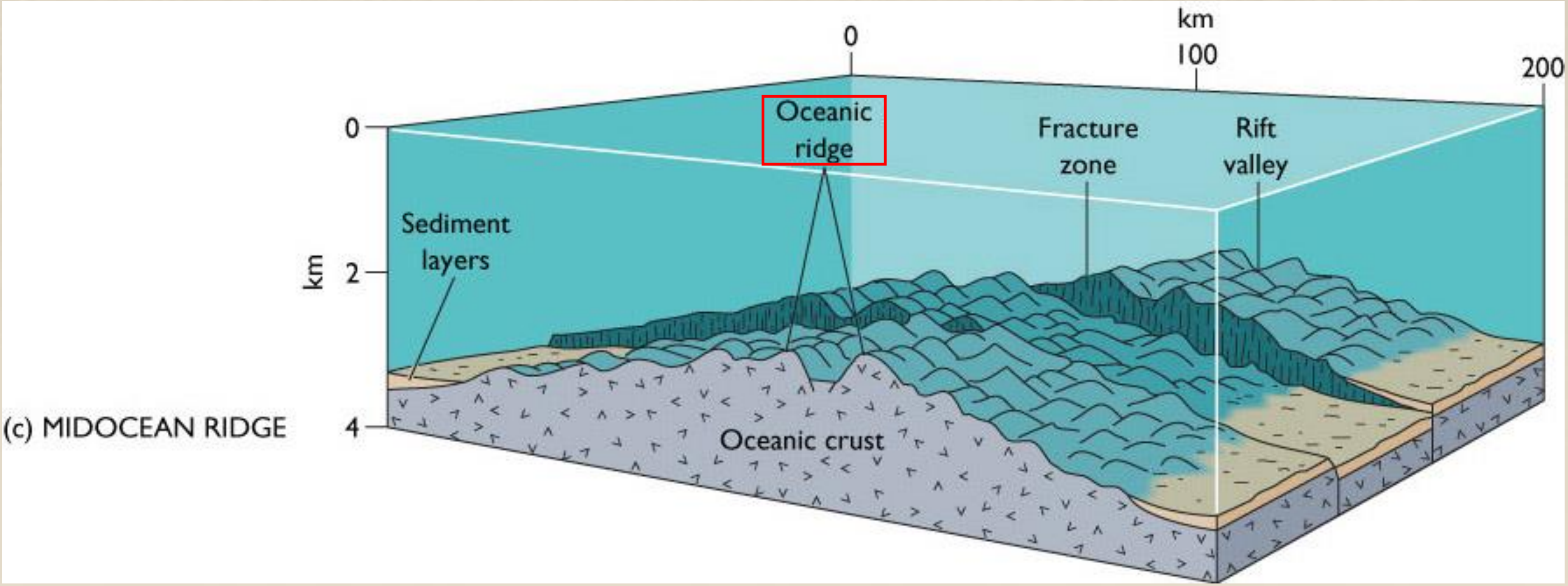

Figure 2-3c Midocean Ridge

Continents and Ocean Basins Differ in Composition, Elevation, and Physiographic Features

- Elevation of Earth’s surface displays a **bimodal** (two peaks) distribution.
  - About 29% above sea level
  - Much of the remainder 4-5 kilometers below sea level

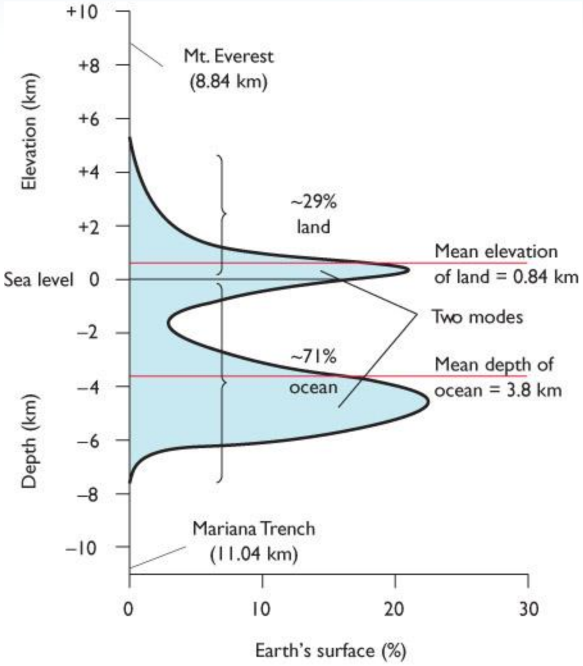

Figure 02.04b: Here is a frequency plot showing the relative distribution of the Earth's land elevations and ocean depths.

Composition, elevation, and physiographic (Continued)

- Continental crust is mainly composed of **granite.**
  - light colored
  - lower density (2.7 gm/cm^3)
  - igneous rock
  - rich in aluminum, silicon and oxygen

- Oceanic crust is composed of **basalt**
  - dark colored
  - higher density (2.9 gm/cm^3)
  - volcanic rock
  - rich in silicon, oxygen, iron and magnesium

- The **Moho** is the boundary between rocks of the crust and the denser (3.3 gm/cm^3) rocks of the mantle, which are mostly silicon, oxygen, iron and magnesium.

Composition, elevation, and physiographic (Continued)

- **Isostasy** refers to the balance of an object "floating" upon a fluid medium.

- Height (elevation) of the mass above the surface of the medium is controlled by:
  - the thickness of the mass
  - the density of the mass (similar to ice floating in water)
  - The density of the medium in (or on) which the mass is floating

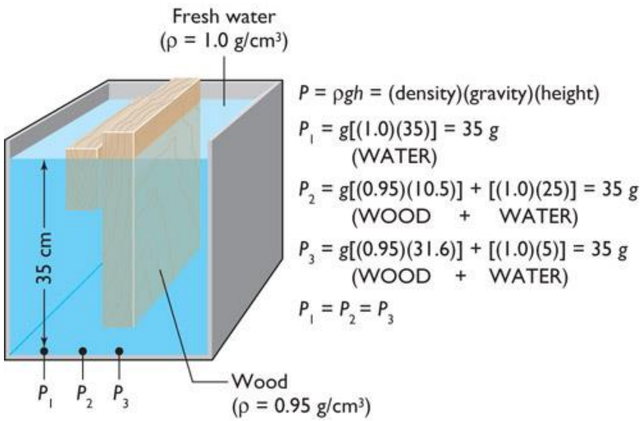

Figure 02.05a: The longer the block, the higher its top rises above the water surface and the deeper its base extends into the water.

Composition elevation, and physiographic (Continued)

- The greater the density of the mass relative to the density of the medium, the lower it will sink in the medium.

- The greater the thickness of the mass, the higher a portion of it will rise above the medium.

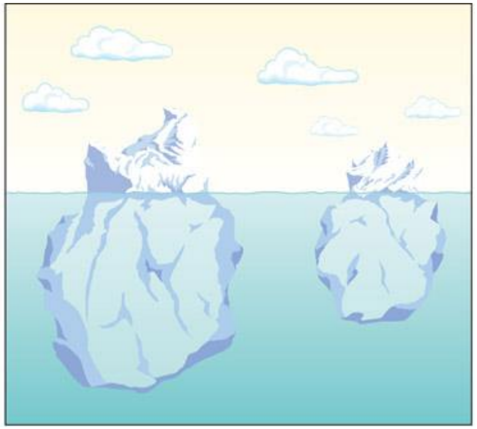

Figure 02.05b: The higher an iceberg rises above the sea surface, the deeper the ice must penetrate into the water in order to maintain isostatic balance.

Isostasy

- Continents are thick (30 to 40 km), have low density and rise high above the supporting mantle rocks.
- Sea floor is thin (4 to 10 km), has greater density and does not rise as high above the mantle.

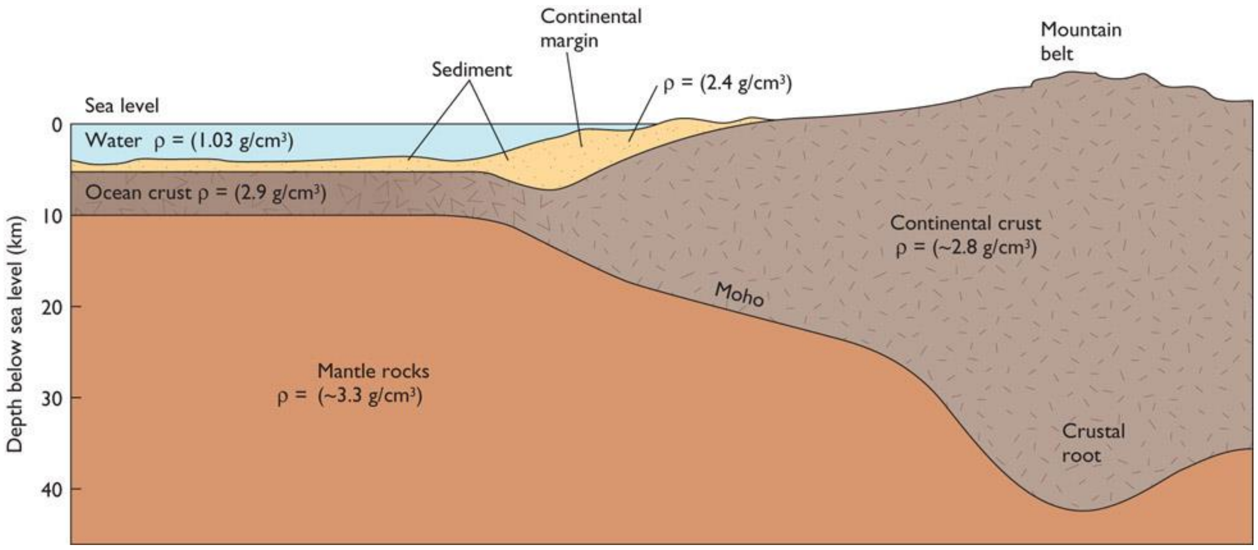

Figure 02.05c: The oceanic crust is denser and thinner than the continental crust.

Composition, elevation, and physiographic (Continued)

- **Altimetry** uses satellites to determine bathymetry.
- Based upon slight changes in the elevation of the sea surface (averaged over time to account for waves and tides).
- These changes result from the greater gravitational attraction of large rock masses on the sea floor, such as volcanoes or the mid-ocean ridges.

Satellite Altimetry

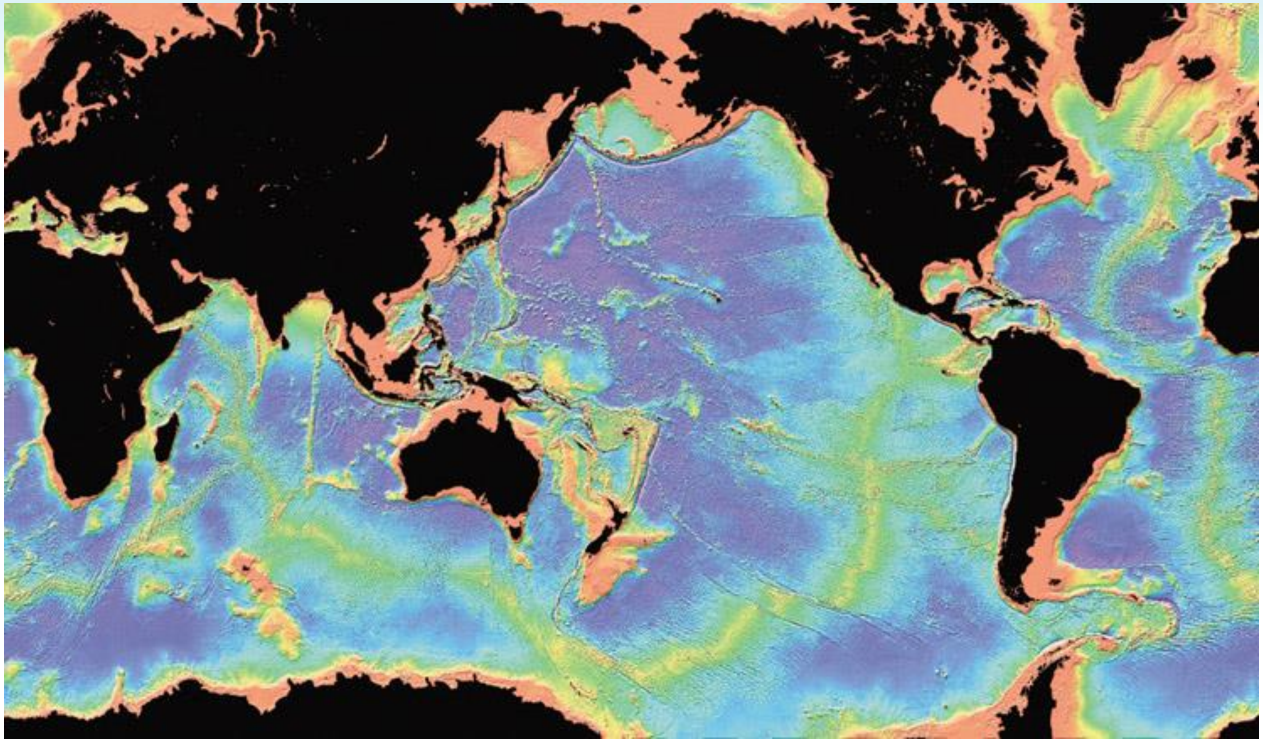

Figure B02.05: Variations in the height of the sea surface reflect the presence of large bathymetric features that affect the elevation of the sea surface.

Echo Sounding and Seismic Reflection

- Echo sounding and seismic reflection rely on sound pulses that reflect off the ocean floor and off sedimentary layers.
- The fundamental relationship between the speed of sound and the density of the material in which the sound is traveling is the key to using these techniques.

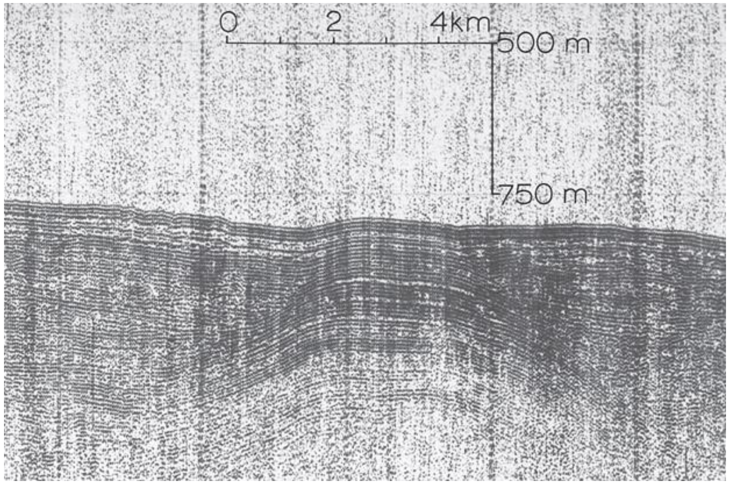

Figure B02.03: Seismic reflection profile. The continuous reflection of sound from subbottom layers (see Figure B2–1) produces a geologic cross section. In this profile, layers of sediment have been deformed into a broad fold.

Echo Sounding and Seismic Reflection

- Seismic refraction examines how sound waves are bent (refracted) as they travel through material.

- They reveal:
  - Densities
  - Depths
  - Thicknesses of rock layers

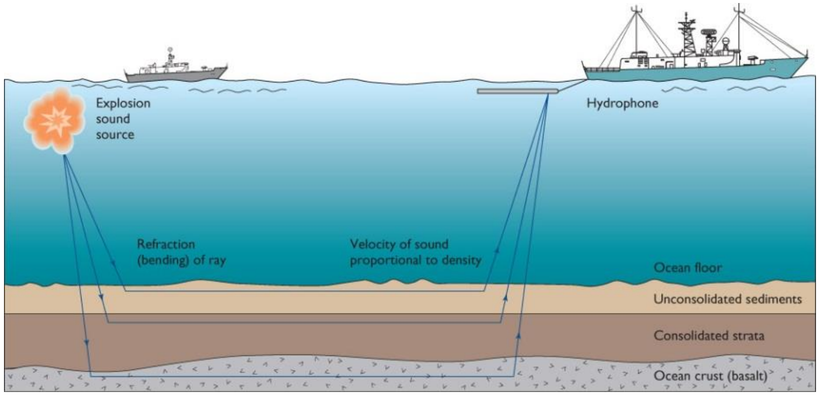

Figure B02.04: The refraction (bending) of sound as it travels through different rock types reveals the shape and density structure of the underlying rock masses.