Marine Science and Oceanography

- **Marine geology**- study of the ocean floor
- **Physical oceanography-** study of waves, currents, and tides
- **Marine biology–** study of nature and distribution of marine organisms
- **Chemical Oceanography**- study of the dissolved chemicals in seawater
- **Marine engineering-** design and construction of structures used in or on the ocean.

Marine Science, or Oceanography, integrates different sciences.

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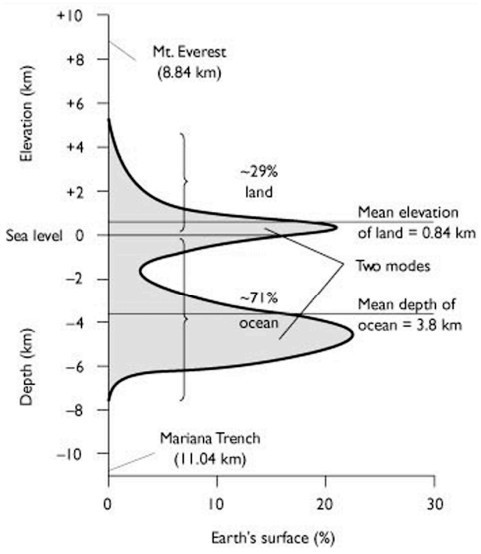


(b) FREQUENCY PLOT OF TOPOGRAPHY AND BATHYMETRY

2

The Sea Floor: Key Ideas

* **The seafloor has two distinct regions: continental margins and deep-ocean basins**

* **The continental margin is the relatively shallow ocean floor near shore. It shares the structure and composition of the adjacent continent.**

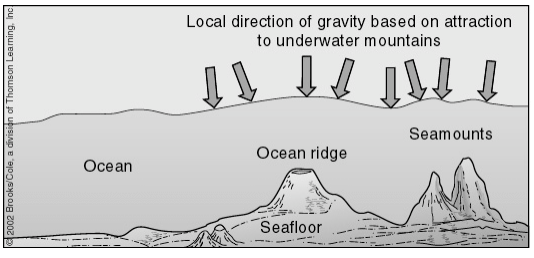
* **The deep-ocean floor differs from the continental margin in tectonic origin, history and composition.**

* **New technology has allowed scientists to accurately map even the deepest ocean trenches.**

3

Bathymetry: The Study of Ocean Floor Contours

Satellite altimetry measures the sea surface height from orbit. Satellites can bounce 1,000 pulses of radar energy off the ocean surface every second.



With the use of satellite altimetry, sea surface levels can be measured more accurately, showing sea surface distortion.

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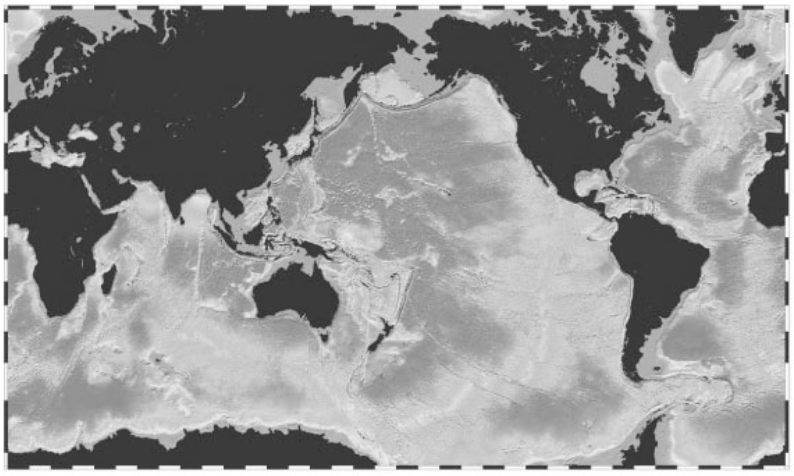

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The Physiography of the Ocean Floor

Physiography and bathymetry (submarine landscape) allow the sea floor to be subdivided into three distinct provinces:

(1) continental margins,
(2) deep ocean basins and
(3) mid-oceanic ridges.

6

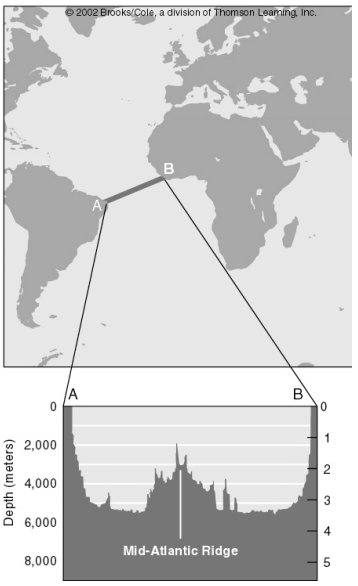
The Topography of Ocean Floors

The classifications of ocean floor:

Continental Margins – the submerged outer edge of a continent

Ocean Basin – the deep seafloor beyond the continental margin

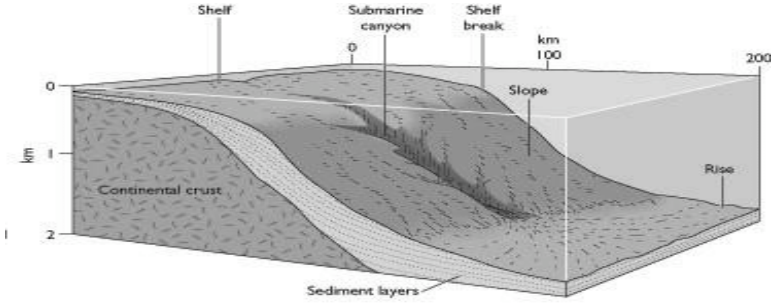
Ocean Ridge System - extends throughout the ocean basins



A typical cross section of the Atlantic ocean basin.

The Continental Margin

Continental margins are the submerged edges of the continents and 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, and the Continental rise.



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Continental Margins

- **Passive margins**, also called Atlantic-type margins, face the edges of diverging tectonic plates. Very little volcanic or earthquake activity is associated with passive margins.
- **Active margins,** known as Pacific-type margins, are located near the edges of converging plates. Active margins are the site of volcanic and earthquake activity.

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Continental Margins

- **Continental shelves** – the shallow, submerged edge of the continent; wide at passive margins.
- **Shelf breaks** – the abrupt transition from continental shelf to the continental slope.
- **Continental slopes** – the transition between the continental shelf and the deep-ocean floor.
- **Continental rises** – accumulated sediment found at the base of the continental slope.

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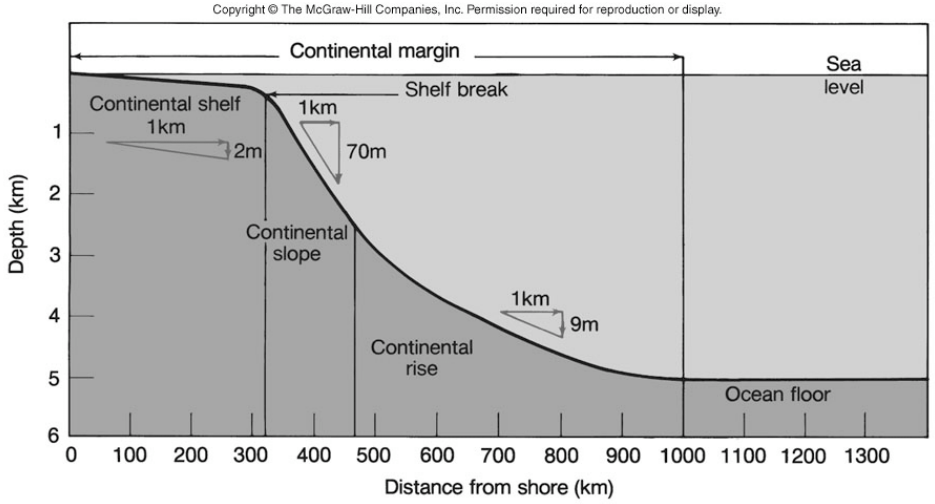

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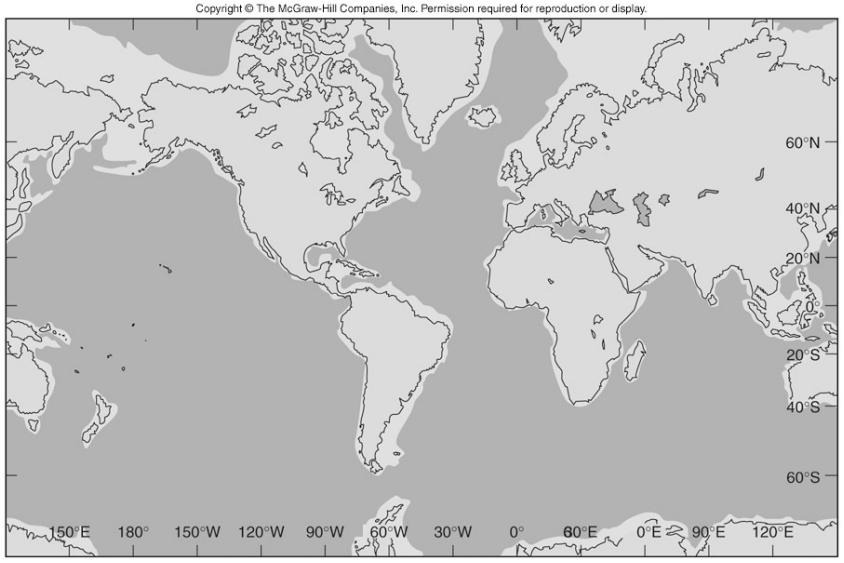
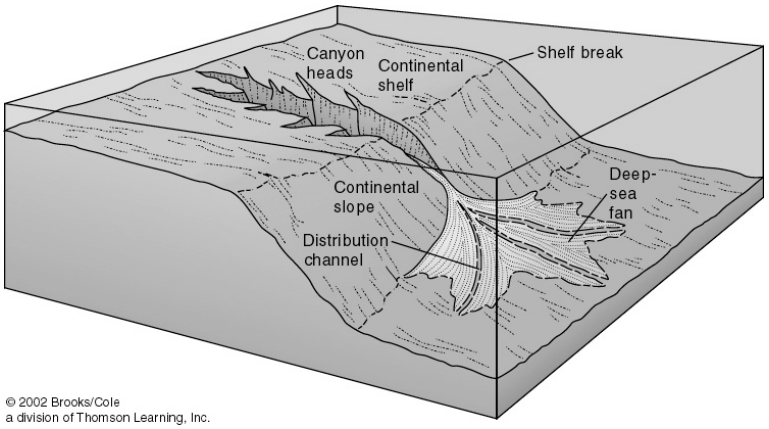
Distribution of Continental Shelves



Submarine Canyons



Hudson canyon, located just offshore of the mouth of the Hudson River, is a typical canyon on a passive continental margin.

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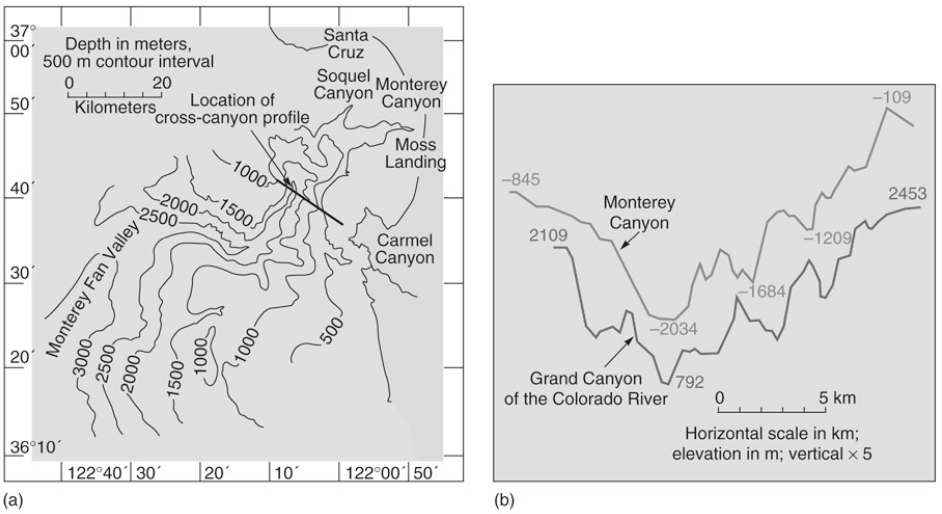

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Features of Deep-Ocean Basins

- Oceanic Ridges
- Hydrothermal Vents
- Abyssal Plains and Abyssal Hills
- Seamounts and Guyots
- Trenches and Island Arcs

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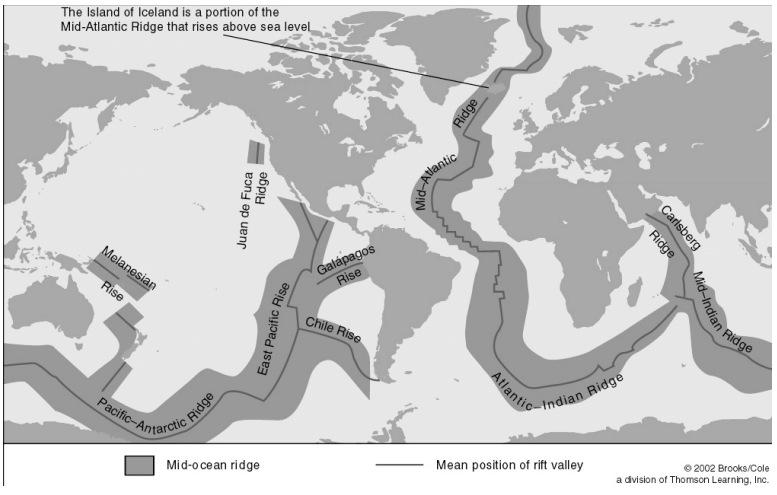
Deep-Ocean Basins



An **oceanic ridge** is a mountainous chain of young, basaltic rock at an active spreading center of an ocean.

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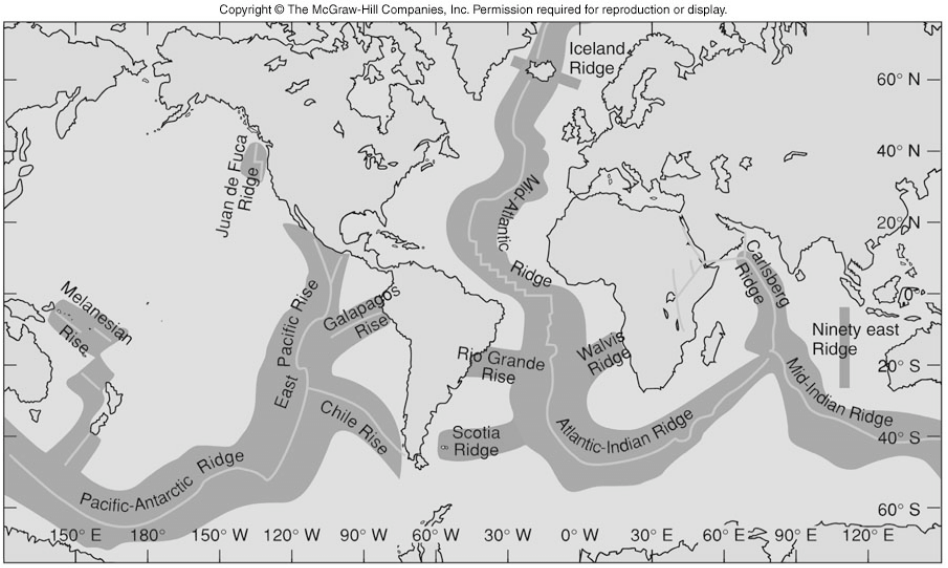

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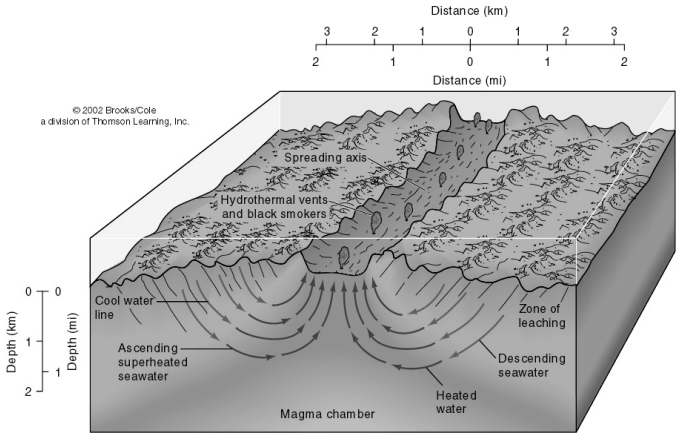
Deep-Ocean Basins

Hydrothermal vents are sites where superheated water containing dissolved minerals and gases escapes through fissures, or vents.



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Deep-Ocean Basins

- **Abyssal plains** are flat areas of sediment-covered ocean floor found between the continental margins and oceanic ridges.
- **Abyssal hills** are small, extinct volcanoes or rock intrusions near the oceanic ridges.
- **Seamounts** are volcanic projections from the ocean floor that do not rise above sea level. Flat-topped seamounts eroded by wave action are called **guyots**.

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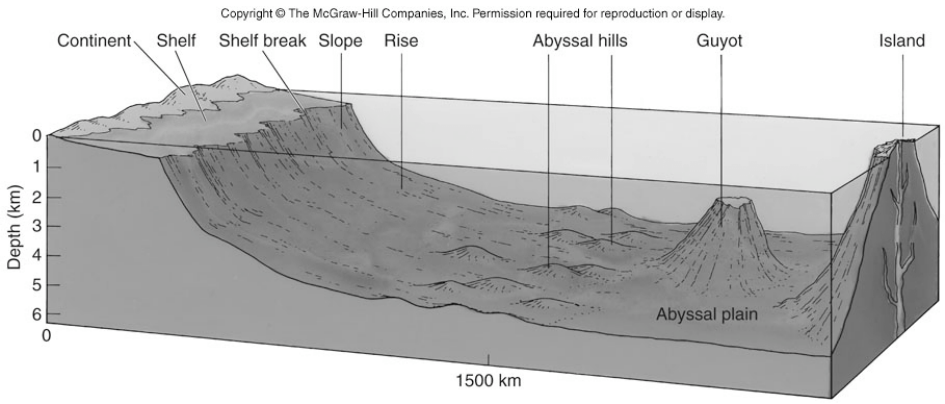

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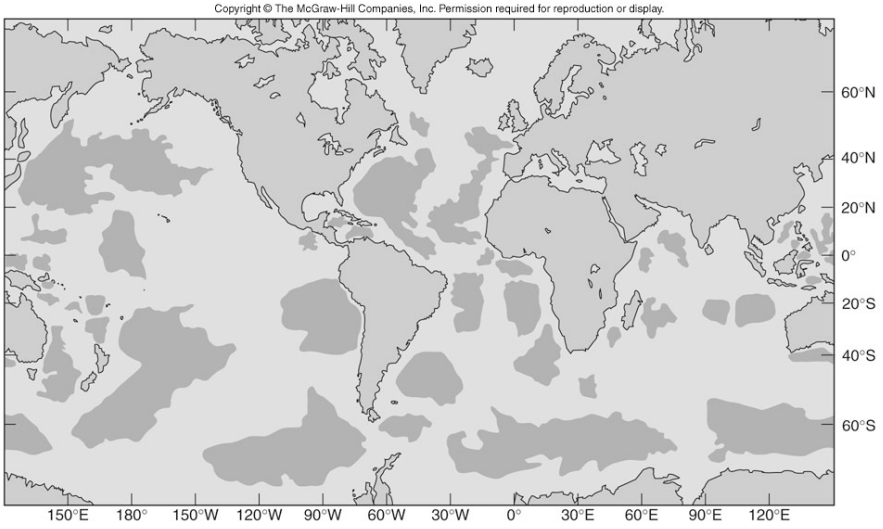
Abyssal Plains



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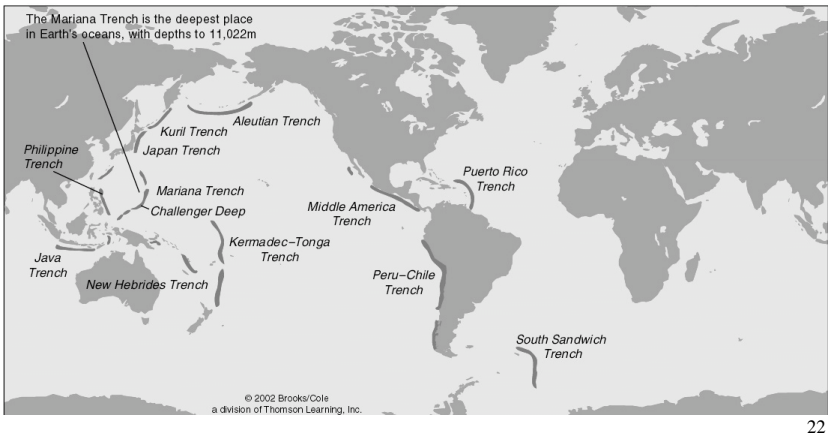
Deep-Ocean Basins

Trenches are depressions in the ocean floor caused by the subduction of a converging ocean plate.



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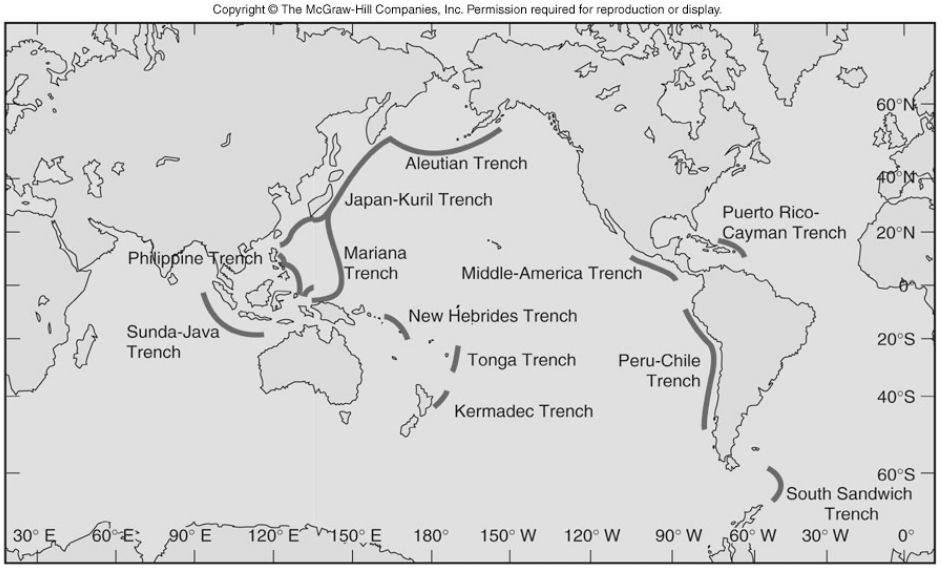

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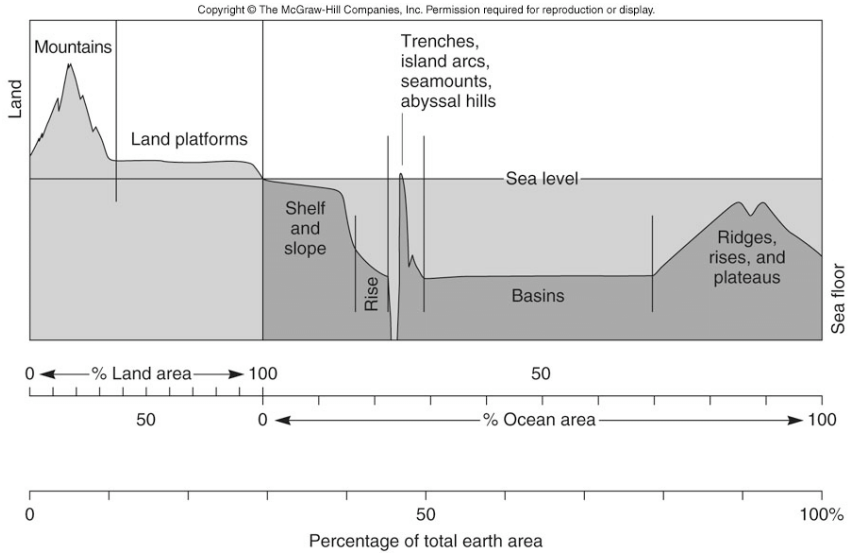

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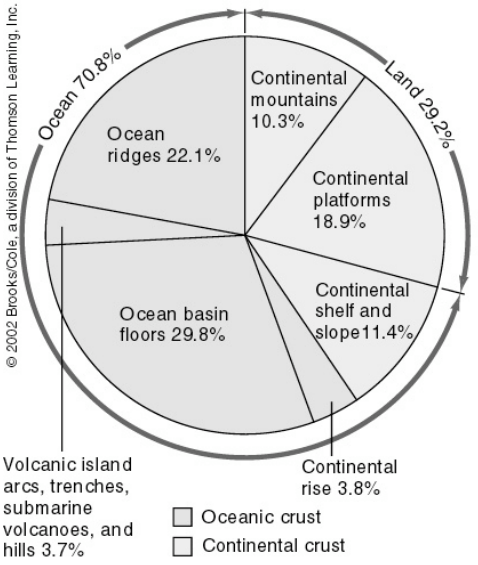
Pie Chart of Earth's Solid Surfaces



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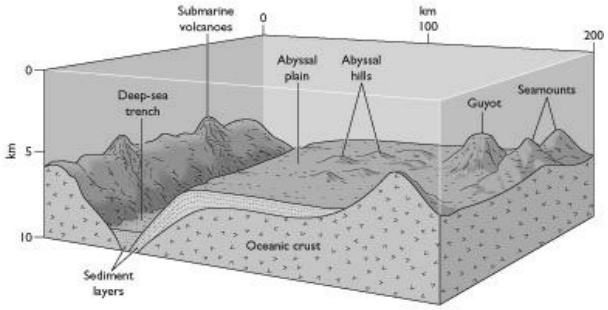
Deep Ocean Basin

Deep Ocean Province is between the continental margins and the midoceanic ridge and includes a variety of features from mountainous to flat plains: Abyssal plains, Abyssal hills, Seamounts, and Deep sea trenches.



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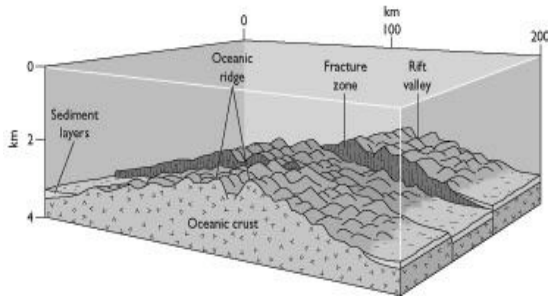
Mid-Ocean Ridge System

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



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Geologic Differences between Continents and Ocean Basins

Elevation of Earth's surface displays a bimodal distribution with about 29% above sea level and much of the remainder at a depth of 4 to 5 kilometers below sea level.
Continental crust is mainly composed of granite, a light colored, lower density (2.7 gm/cm^3) igneous rock rich in aluminum, silicon and oxygen.

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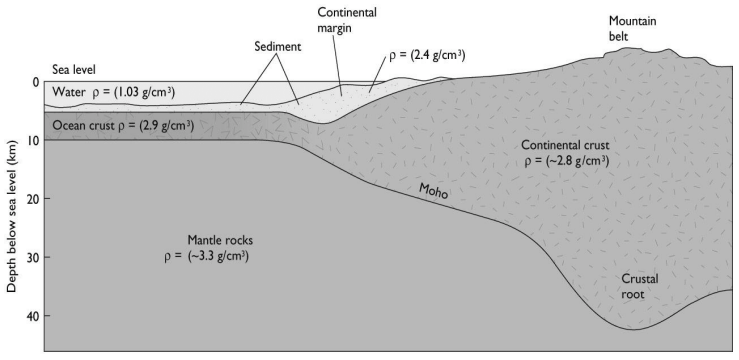
Geologic Differences between Continents and Ocean Basins

Oceanic crust is composed of basalt, a dark colored, higher density (2.9 gm/cm^3) volcanic rock rich in silicon, oxygen and magnesium.
The Moho is the boundary between rocks of the crust and the denser (3.3 gm/cm^3) rocks of the mantle.

29

Oceanic Crust Versus Continental Crust

Sea floor is thin (4 to 10 km), has greater density and does not rise as high above the mantle.



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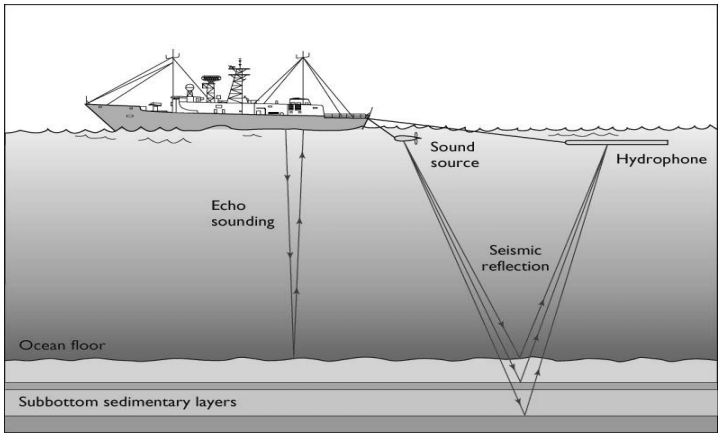
Geophysical Surveying

Echo sounding and seismic reflection rely on sound pulses that reflect off the ocean floor and off sedimentary layers.



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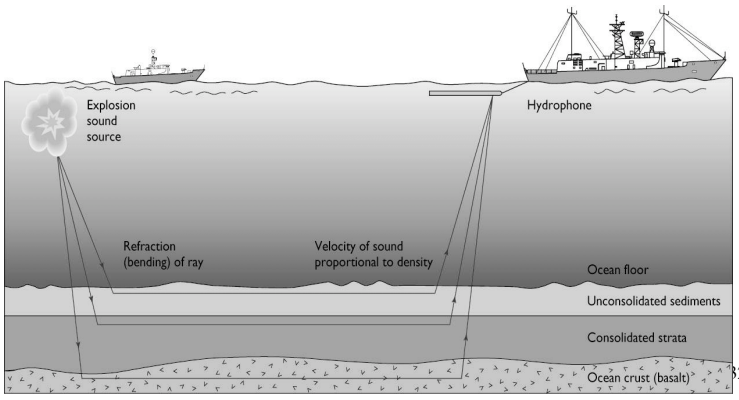
Geophysical Surveying

Seismic refraction examines how sound waves are bent (refracted) as they travel through material. They reveal densities, depths, and thicknesses of rock layers.



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A Layered Earth - Density

- **Density** is a key concept for understanding the structure of Earth.
- Density measures the mass per unit volume of a substance.
- Density = Mass/Volume (g/cm^3)
- Water has a density of ~1 g/cm^3
- Density changes occur due to temperature changes.

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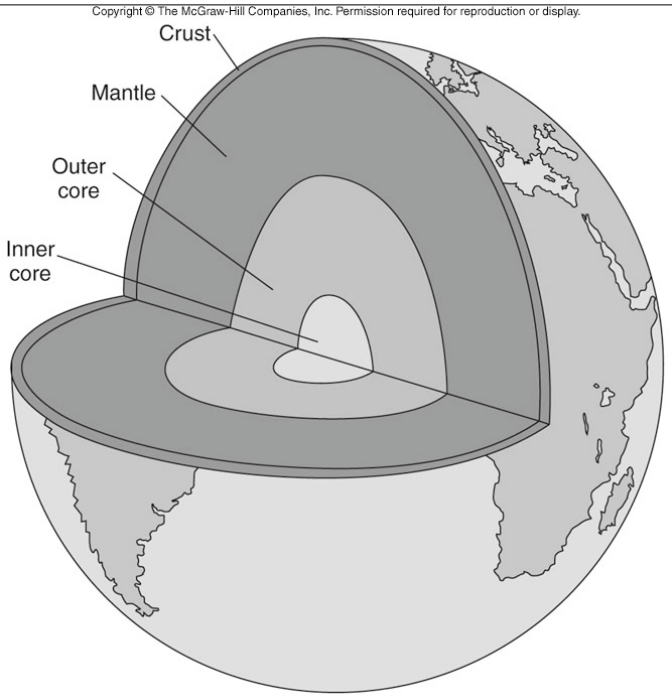

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Table 2.1 Layers of the Earth

Layer	Depth (km)	Thickness (km)	State	Composition	Density (g/cm^3)	Temperature (°C)
Crust						
Continental	0–65	40 (average)	Solid	Silicates rich in sodium, potassium, and aluminum	2.67	–89–1000
Oceanic	0–10	7 (average)	Solid	Silicates rich in calcium, magnesium, and iron	3.0	0–1100
Mantle	Base of crust–2891	2866	Solid and mobile	Magnesium-iron silicates	3.4–5.6	1100–3200
Outer core	2891–5149	2258	Liquid	Iron, nickel	9.9–12.2	3200
Inner core	5149–6371	1222	Solid	Iron, nickel	12.8–13.1	4000–5500

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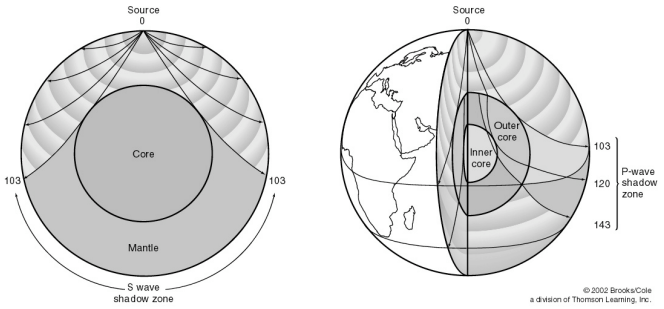
Layered Earth - Evidence Of Earth's Layers



What evidence supports the idea that Earth has layers?

- The behavior of seismic waves generated by earthquakes give scientists some of the best evidence about the structure of Earth.
- S waves cannot penetrate Earth's liquid core.
- P waves are bent as they pass through the liquid outer core.

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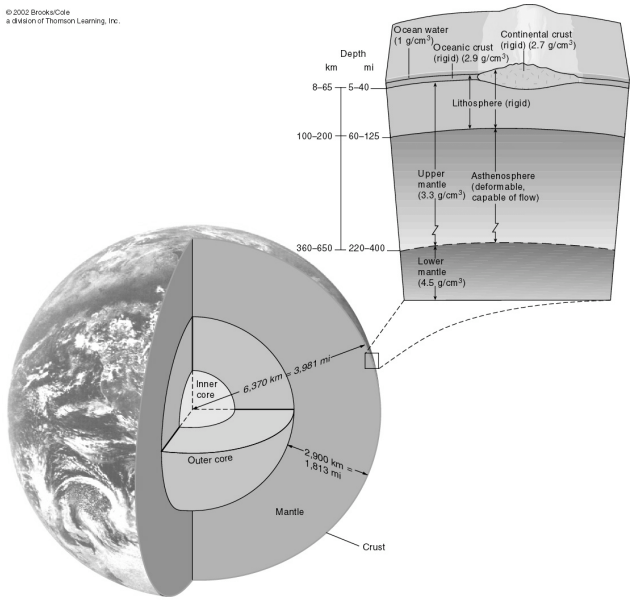
Layered Earth



A cross section of Earth showing the internal layers. These layers can be described by their chemical and physical characteristics.

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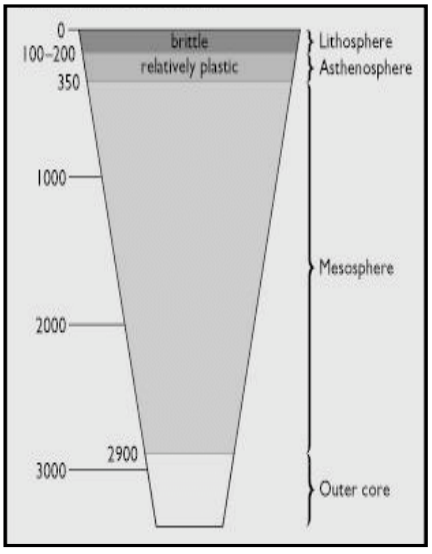
Layered, Internal Structure of the Earth



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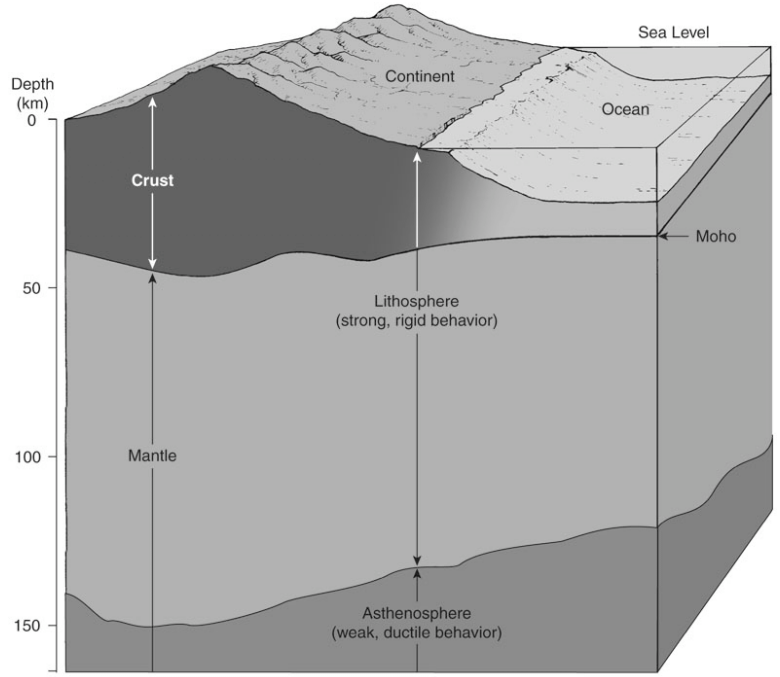

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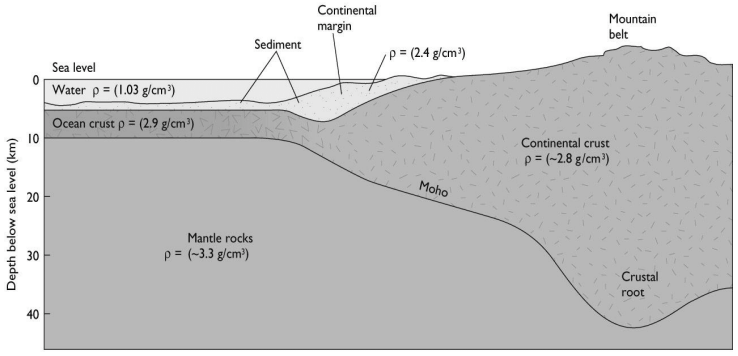
Oceanic Crust Versus Continental Crust

Sea floor is thin (4 to 10 km), has greater density, and does not rise as high above the mantle.



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Layered Earth - Physical Properties

Physical Properties of Earth's Layers	
Layer	**Physical Properties**
Lithosphere	The cool, rigid outer layer
Asthenosphere	Hot, partially melted layer which flows slowly
Mantle	Denser and more slowly flowing than the asthenosphere
Outer Core	Dense, viscous liquid layer, extremely hot
Inner Core	Solid, very dense and extremely hot

A cool, rigid, less dense layer (the lithosphere) floats on a hot, slowly-flowing, more dense layer (the asthenosphere).

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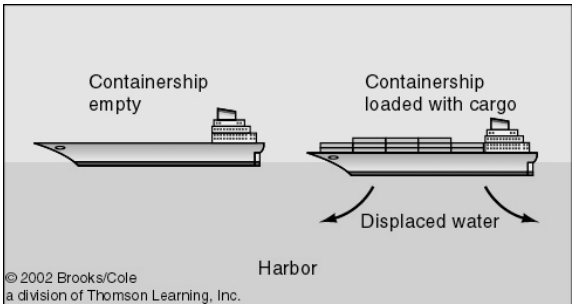
Isostatic Equilibrium

Why doesn't the lithosphere sink into the asthenosphere? How are features such as mountains supported?

The concept of **buoyancy** is illustrated by a ship on the ocean. The ship sinks until it displaces a volume of water equal to the weight of the ship and its contents.

Earth's lithosphere is supported on the asthenosphere in a similar manner. Instead of buoyancy, the term **isostatic equilibrium** describes the way the lithosphere is supported on the asthenosphere.



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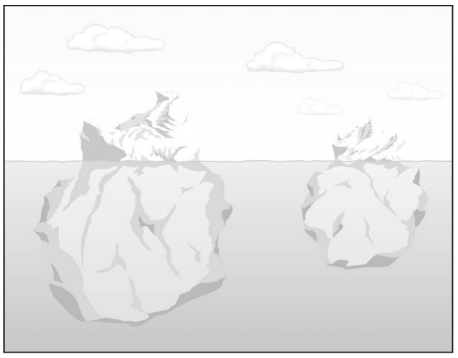
Isostasy

Isostasy refers to the balance of an object "floating" upon a fluid medium. Height of the mass above and below the surface of the medium is controlled by the thickness of the mass and its density (similar to ice floating in water).



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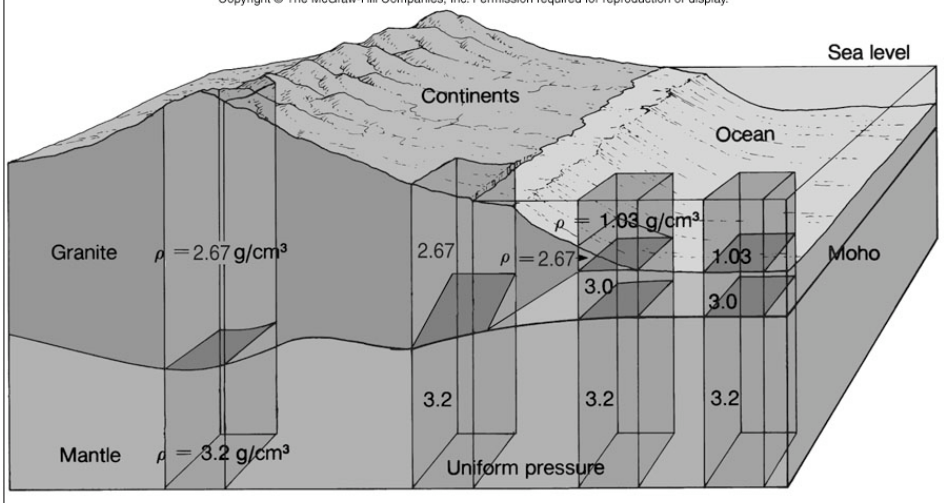

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Isostasy

- Greater the density of the mass, the lower it will sink in the medium.
- Greater the thickness of the mass, the higher a portion of it will rise above the medium.
- Continents are thick (30 to 40 km), have low density and rise high above the supporting mantle rocks.

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