

The Ocean Floor

Oceanography

- Oceanography is an interdisciplinary science that draws on geology, chemistry, physics, and biology to study all aspects of the worlds oceans
- Almost 71% of the Earth's surface is covered with water

Land vs. Water

- The continents and the oceans are not evenly divided between hemispheres
 - In the northern hemisphere, 61% of the surface is water
 - In the southern hemisphere, 81% of the surface is water

The Oceans

- The worlds oceans can be divided into five primary bodies
 - Pacific
 - Atlantic
 - Indian
 - Arctic
 - Southern

The Oceans

- Pacific
 - Largest ocean
 - Largest geographical feature on earth
 - Accounts for over half of the entire ocean surface
 - Average depth ~3,940 meters (13,000 feet)



http://www.mapsworldwide.com/itm_img/1840061022.jpg

The Oceans

- Atlantic
 - About half the size of the Pacific and bounded by almost parallel continental margins



<http://www.orangesmile.com/ru/foto/oceans/atlantic-ocean-map.jpg>

The Oceans

- Indian
 - Slightly smaller than the Atlantic but has roughly the same average depth
 - Mostly in the southern hemisphere



http://www.islandguide.biz/indian/images/indian_ocean_map.jpg

The Oceans

- Arctic
 - Only ~7% as big as the Pacific and roughly 25% as deep as the other oceans



http://www.lib.utexas.edu/maps/ica98/arctic_ocean_sm98.jpg

The Oceans

- Southern
 - Found below 50° south parallel
 - Encircles Antarctica
 - Distinguished by significant changes in temperature, salinity, and fauna

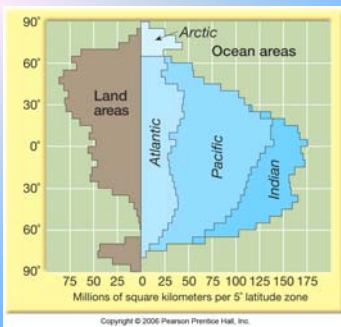


<http://zhenghe.tripod.com/maps/southernocean.jpg>

The Oceans



The Oceans



Bathymetry

- The ocean floor is nearly as varied as the land surface
- Marked with distinctive features such as plateaus, trenches, mountain ranges, and volcanic peaks
- Our understanding of the ocean floor came with the development of bathymetry

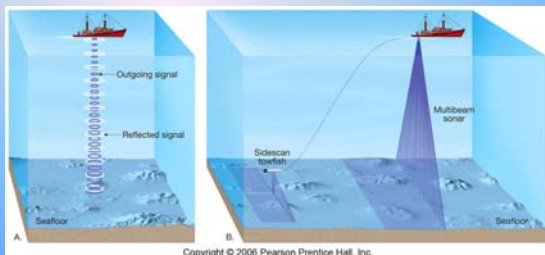
Bathymetry

- A sound (ping) is emitted and while traveling through water, will reflect off of any solid surface it encounters
- By measuring the time it takes for the ping to travel and be reflected, while noting the speed of sound in water (~1,500 meters per second), a picture of the ocean can be derived

Bathymetry

- High-resolution images can be obtained by using hull-mounted sound sources that send out pings in a fan shape swath
- The resulting reflections are then recorded through a set of receivers
- Can acquire a swath tens of kilometers wide and depths can be distinguished up to a meter

Bathymetry



Ocean Floor Provinces

- Oceanographers have delineated three primary oceanographic units (provinces)
 - Continental margins
 - Deep-ocean basins
 - Mid-ocean ridge

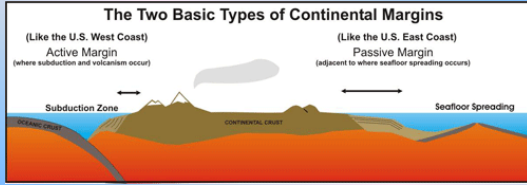
Continental Margins

- Two primary types of continental margins
 - Active
 - Occur where oceanic crust is being subducted beneath the edge of a continent
 - Associated with earthquakes and volcanic activity
 - Characterized by a narrow band of highly deformed sediment
 - Common around the Pacific Rim
 - Typically parallel to ocean trenches

Continental Margins

- Two primary types of continental margins
 - Passive
 - Found along most coastal areas bordering the Atlantic Ocean
 - Not associated with any plate boundary
 - Little to no earthquake and volcanic activity
 - Characterized by weathered materials deposited by rivers to form a thick, broad wedge of relatively undisturbed sediment

Continental Margins



http://sio.ucsd.edu/png/science/images/margin-types_sm.gif

Passive Margins

- Passive margins are comprised of a
 - continental shelf
 - continental slope
 - continental rise

Passive Margins

- Continental Shelf
 - A gently sloping submerged surface extending from the shore to the deep ocean basin
 - Underlain by continental crust and recognized as a flooded extension of a continent
 - Varies in width
 - From a few miles to ~900 miles wide
 - Average ~50 miles

Passive Margins

- Continental Shelf
 - The slope is very gently, ~2 meters per kilometer (~10 feet per mile)
 - To an observer, may appear as a horizontal surface
 - Accounts for only ~7.5% of the ocean surface but important due to resources found
 - Sand and gravel, minerals, oil and gas, among others

Passive Margins

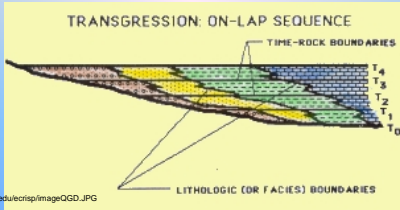
- Continental Shelf
 - Fluctuations in sea level can be discerned when studying sedimentation patterns on continental shelves
 - Transgressions
 - Regressions

Passive Margins

- Transgressions and regressions
 - During periods of low sea level, waves would batter the newly exposed shore, erosion would deepen valleys and rivers would deposit sediment further into the basin
 - As sea level rose, these areas were flooded and sediments would build up closer to the shore

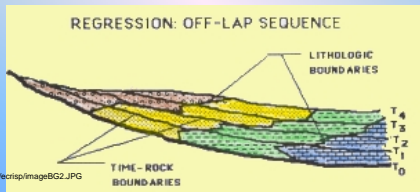
Passive Margins

- Transgressions
 - In a stratigraphic sequence, a transgressive sequence is noted if the sediments become increasingly **finer** toward the top of the sequence



Passive Margins

- Regressions
 - In a stratigraphic sequence, a regressive sequence is noted if the sediments become increasingly **coarser** toward the top of the sequence



The Continental Slope

- A relatively steep feature that marks the boundary between the continental crust and the oceanic crust
- Slope averages ~5 degrees but may exceed 25 degrees
- Average width is small, averaging 20 kilometers (12 miles)

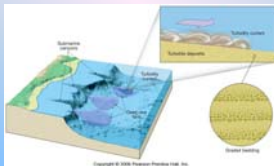
The Continental Slope

- Submarine canyons are one of the most distinguishing features
- These canyons usually represent extensions of rivers and were carved during periods of low sea level
- They are steep sided and have a V-shaped cross section
- Erosion can continue even after submergence through the action of turbidity currents

Turbidity Currents

- Dense, sediment-laden water becomes dislodged and flows downward to the deep ocean basin
- Can travel ~56 mph and carry up to 300 kg of sediment per cubic meter (18.7 lbs/sq. ft.)
- Usually attributed to earthquakes or overloading of sediment
- Will come to rest on the deep ocean floor
- As sediment comes to rest, coarser materials settle faster than finer sediments
- Will form turbidites, characterized by graded bedding (fining upward)

Graded Bedding



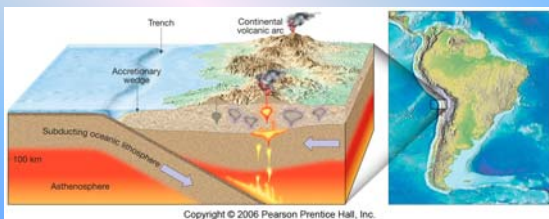
The Continental Rise

- The continental slope eventually merges into a gradual incline
- The slope is ~6 meters per kilometer (32 feet per mile)
- May extend for hundreds of kilometers into the deep ocean basin
- The rise consists of a thick accumulation of sediment that moved under the action of turbidity currents.
 - When these currents leave the confines of the canyon and emerge onto the ocean floor, they produce a feature known as a deep-sea fan.
 - As fans from adjacent canyons grow, they merge laterally with other fans to produce the continental rise.

Active Margins

- Along active margins, the continental shelf ends abruptly at the deep ocean trench
- At this location, the sediment of the ocean crust is scraped from the descending plate and plastered against the edge of the overriding continent
- This chaotic assemblage is the accretionary wedge

Active Margins



Deep Ocean Basin

- The size of this region is comparable to the size of the land on the surface
- This region includes abyssal plains, volcanic peaks (guyots), and trenches

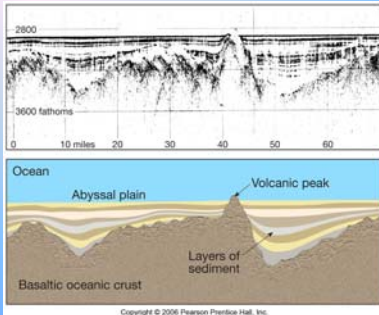
Deep Ocean Basin

- Deep ocean trenches
 - Long, relatively narrow creases in the ocean floor
 - Form the deepest parts of the ocean
 - Usually located on the margins of continents in the Pacific
 - Marianna Trench - ~36,163 feet deep

Deep Ocean Basin

- Abyssal Plains
 - Deep, very flat features
 - Some of the most level plains on the earth
 - Off Argentina, less than 10 feet relief over ~800 miles
 - Featureless topography due to the massive accumulation of sediment
 - Likely buried more rugged topography
 - Most extensive plateau in the Atlantic
 - Few trenches to trap sediment

Abyssal Plains

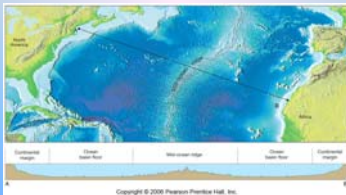


Deep Ocean Basin

- Seamounts
 - Volcanic seamounts
 - Estimated near 1 million, these volcanic features can rise more than 100 meters off the sea floor
 - Similar to volcanic mountains but most do not breach the water surface
 - Most associated with hotspots or divergent plate boundaries
 - Over time, as they move from their source, they will be lowered by erosion and may lie submerged beneath the water surface
 - Will form a flat-topped surface called a guyot

Deep Ocean Basin

- Mid-Ocean Ridge
 - Found along divergent plate boundaries
 - Winds through all the world's oceans like seams on a baseball
 - Crest of the ridge typically stands ~2-3 kilometers above the surrounding ocean floor



Sea Floor Sediment

- Most of the ocean floor is covered with sediment
- Thicknesses can range from 1,500 feet to 6 miles
- Most common type of sediment: mud
- Classified into three types
 - Terrigenous
 - Biogenous
 - Hydragenous

Sea Floor Sediment

- Terrigenous
 - Consists of mineral grains weathered from continental rocks
 - Larger particles typically found closer to the shore
 - Finer particles can take years to settle out of suspension and are typically found further from the shore
 - Finer sediments can travel thousands of kilometers, carried by ocean currents

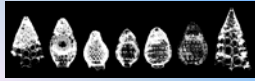
Sea Floor Sediment

- Biogenous
 - Consists of shells and skeletons of marine organisms
 - Mostly microscopic
 - Mostly calcareous (calcium carbonate)
 - Not usually found in the deep ocean basins
 - May also be siliceous (silica-based)
 - Examples
 - Diatoms
 - Radiolarians
 - Foraminifera

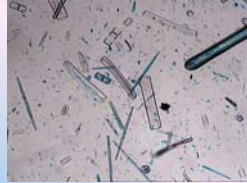
Biogenous Sediment



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<http://www.ucmp.berkeley.edu/protista/radiolaria/rads.html>

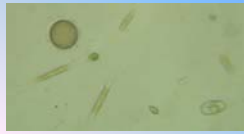


<http://sciences.aum.edu/Bi/bi1020/hall/diatoms.jpg>

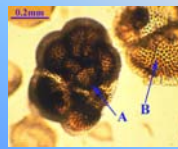
Biogenous Sediment



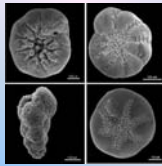
<http://universe-review.ca/11-31-diatoms.jpg>



<http://romunov.blogspot.com/images/diatoms.jpg>



<http://www.biology.usberta.ca/courses/hpzod250/Labs/Lab02/Foraminifera.gif>



http://www.knowledgenash.com/wiki/Image:thumb/0/00/00px-Benthic_foraminifera.jpg

Sea Floor Sediment

- Hydrogenous
 - Consists of minerals that crystallize directly from sea water
 - Usually a small portion of sediment
 - Includes
 - Manganese nodules
 - Calcium carbonate
 - Metal sulfides
 - Evaporites

Ocean Resources

- Oil and Natural Gas
 - Represent ~95% the value of all resources extracted from the ocean
 - Almost always associated with sedimentary rock deposits
 - Produced by the conversion of organic material into hydrocarbons

Ocean Resources

- Gas Hydrates
 - Combination of natural gas (usually methane) and water
 - Forms a solid, ice-like structure under pressure at low temperatures
 - Can melt and bubble at the surface as gas escapes
 - Important for three reasons
 - Potential source of energy
 - May contribute to slumping along continental margins
 - May play a role in climate change

Ocean Resources

- Sand and Gravel
 - Used in construction
 - World produces ~1.2 billion metric tons per year

Ocean Resources

- Manganese nodules
 - Scattered around the deepest parts of the world's oceans
 - Composition
 - 30% Mn
 - 1% Cu
 - 1.25% Ni
 - 0.25% Co
 - Cobalt is the precious resource
 - Classified as being of strategic importance to US
 - Used to build strong alloys in tools and engines
