Hewitt/Lyons/Suchocki/Yeh

Conceptual Integrated Science

Chapter 24

EARTH'S SURFACE—
LAND AND WATER

Earth's Many Landforms

Earth consists of seven continents:
Africa, Antarctica, Asia, Australia, Europe, North America, and South America

Continental elevations vary between
- Mt. Everest (8848 m)
- Dead Sea shores (–400 m)

Earth's Many Landforms

Earth has three oceans:
The Pacific Ocean - largest, deepest, and oldest
The Atlantic Ocean - Coldest and saltiest
The Indian Ocean - Smallest

BUT, the oceans are all connected

Earth's Many Landforms

- Continental land features - High mountains, plateaus, lowland plains
- Ocean features - Deep trenches to mid-ocean ridge system
- Tectonic force and landforms - Folds, faults, mountains
- Erosive force and landforms - Valleys, canyons, deltas, and floodplains

Crustal Deformation

Deformation is a general term that refers to all changes from the original form and/or size of a rock body. Rocks deform because they are subjected to stress.

Most crustal deformation occurs along plate margins.

Crustal Deformation

Compressional stress—convergent plate boundary
- Pushing together of rock masses

Tensional stress—divergent plate boundary
- Pulling apart of rock masses

Shear stress—transform fault-plate boundary
- Rock masses sliding past one another

Crustal Deformation

Elastic deformation
- Size and shape deform, but rock returns to original form when stress is removed

Fracture
- Elastic limit of rock exceeded; rock breaks
- Colder, surface rock

Plastic deformation
- Elastic limit of rock exceeded; shape changed permanently—folds
- Warmer, subsurface rock

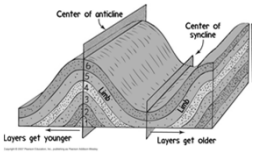
Folds

During crustal deformation, rocks are often bent into a series of wave-like undulations called *folds.*

Most folds result from compressional stresses that shorten and thicken the crust.

Folds

- Anticlines - upfolded or arch-shaped rock layers.
  - Oldest rock layers at the fold core, rock layers get younger away from core.
- Synclines - downfolds or trough-shaped rock layers.
  - Youngest rocks at the fold core, rock layers get older away from the core.



Faults

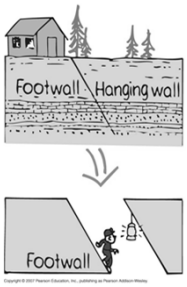
Faults are fractures with displacement.

Faults classified by *relative* displacement :
- Dip-slip (vertical)
- Strike-slip (horizontal)
- Oblique (combination)

Sudden fault movement causes most earthquakes.

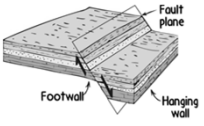
Dip-Slip Faults

Dip-slip fault movement is up or down
- Footwall—rock below the fault surface where a miner could stand.
- Hanging wall—rock above the fault surface where a miner could hang a lamp.

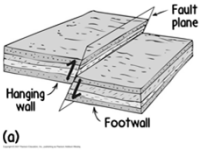


Dip-Slip Faults

Normal fault: hanging wall moves *down* relative to footwall; happens under tension

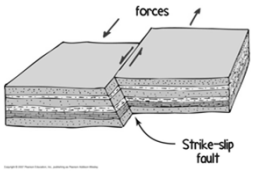


Reverse fault: hanging wall moves *up* relative to footwall; happens under compression



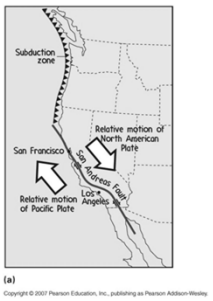
Strike-Slip Faults

Displacement is horizontal, right-lateral, or left-lateral depending on direction of movement.



Strike-Slip Faults

Transform plate boundary: Large strike-slip fault that cuts through the lithosphere, accommodates motion between two tectonic plates



Oblique-Slip Faults

Faults with combined motion:

- Move horizontally as in a strike-slip fault
- Move vertically as in a dip-slip fault
- Oblique faulting occurs when tensional and shear forces or compressional and shear forces exist.

Mountains

Mountains are thick sections of crust elevated with respect to the surrounding crust.

Mountains are classified according to their structural features:

- Folded Mountains
- Upwarped Mountains
- Fault-Block Mountains
- Volcanic Mountains

Folded Mountains

Folded mountains usually occur at convergent plate boundaries - crustal thickening causes uplift.

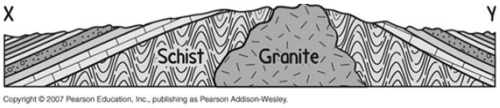
- Compression folds, thickens, and shortens the crust

Continental collision creates highest mountains

Upwarped Mountains

Broad upwarping of deeper rock deforms overlying sedimentary rock, producing roughly circular structures called domes.

- Older rocks are in the center, and younger rocks are on the flanks. Ex: Black Hills



Fault-Block Mountains

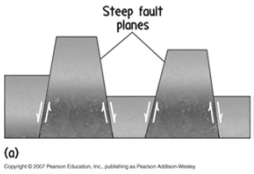
- Fault-block mountains occur within large areas of broad uplift.
  - Overall force is usually compression, but the crust is also stretched in such settings
  - Example: When a tree branch is bent, compression occurs on the inside of the bend and tension occurs on the outside of the bend.

Fault-Block Mountains

Normal faults in stretched crust let huge blocks drop downward.

Block left standing is the mountain. Broad uplift continues.

Examples: The Sierra Nevadas, The Grand Tetons, The Basin and Range



Volcanic Mountains

Most volcanoes form near plate boundaries where converging plates meet.

About 75% of the world's volcanoes are found in the "Ring of Fire" that encircles the Pacific Ocean.

Volcanic Mountains

Volcanic mountains formed by eruptions of lava, ash, and rock fragments.

Opening at the summit of a volcano:

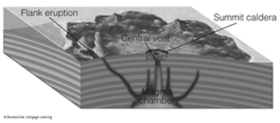
- Crater: steep-walled depression at the summit, less than 1 km in diameter
- Caldera: summit depression greater than 1 km diameter, produced by collapse following a massive eruption

Vent - an opening connected to the magma chamber

Volcanic Mountains

Shield volcano:

- Broad, large, slightly dome-shaped volcano
- Composed primarily of basaltic lava
- Mild eruptions of large volumes of lava
- Mauna Loa on Hawaii



Volcanic Mountains

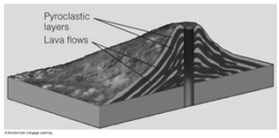
Cinder cone:

- Ejected lava (mainly cinder-sized) fragments
- Steep slope angle, small in size
- Sunset Crater in Arizona

Volcanic Mountains

Composite cone:

- Large, classic-shaped volcano
- Composed of interbedded lava flows and alternating layers of ash, cinder, and mud
- Very violent, explosive volcanic activity (Mt. Vesuvius)
- Many are located adjacent to the Pacific Ocean



Volcanic Mountains

Hot spots—stationary, deep, very hot. Hot mantle rock moves upward by convection.

Hot spot volcanism:

- Partial melting occurs near the surface; localized volcanism in the overriding plate
- In oceanic crust, basaltic magma produced - Hawaiian Islands
- In continental crust, granitic magma produced - Yellowstone National Park

Earth's Waters

Earth is 71% covered by water: ~97% is saltwater in the oceans; ~3% is fresh water.

- ~2% is frozen in ice caps and glaciers.
- ~1% is liquid fresh water in groundwater, and water in rivers, streams, and lakes.
- A small amount is water vapor.

Earth's waters are constantly circulating. The driving forces are

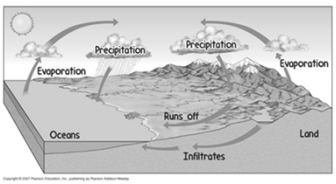
- Heat from the Sun
- Force of gravity

Earth's Waters

The hydrologic cycle is the set of processes that controls the circulation of water on Earth.

Processes involved in the hydrologic cycle:

- Evaporation
- Precipitation
- Infiltration
- Runoff



The Ocean Floor

Ocean floor encompasses continental margins and deep ocean basins.

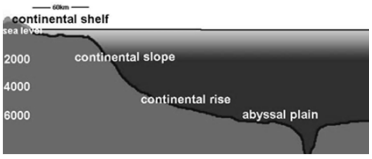
Continental margins are between shorelines and deep ocean basins.

The Ocean Floor

Continental shelf—shallow; underwater extension of the continent.

Continental slope—marks boundary between continental and oceanic crust.

Continental rise—wedge of accumulated sediment at base of continental slope.



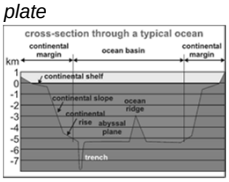
The Ocean Floor

Features of active margins:

Continental shelf—often narrow and steeply sloping

Continental slope—may be the wall of an ocean trench

Accretionary wedge—formed from rock scraped off of subducting plate



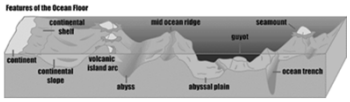
The Ocean Floor

The ocean bottom is not flat, it is etched with deep canyons, trenches, crevasses.

Underwater mountains rise upward from the seafloor.

The deep-ocean basin:

- Basalt from seafloor spreading plus thick accumulations of sediment
- Abyssal plains, ocean trenches, and seamounts



The Ocean Floor

The deepest parts of the ocean are at the ocean trenches near some of the continents.

The shallowest waters are in the middle of the oceans around underwater mountains (mid-ocean ridge system).

Ocean Water

Ocean water is a complex solution of mineral salts, dissolved gases, and decomposed biological material.

Salinity: the proportion of salts to pure water.

- ~35 grams salts per 1000 grams of water

Salinity and temperature control density

- Salty, cold water is denser than less salty, warmer water

Table 24.1 Abundant Salts of the Sea

Salt of seawater	Weight per 1000 grams
Sodium chloride (NaCl)	23.48 g
Magnesium chloride ($MgCl_2$)	4.98 g
Sodium sulfate (Na_2SO_4)	3.92 g
Calcium chloride ($CaCl_2$)	1.10 g
Sodium fluoride (NaF)	0.66 g
Total:	34.8 g

Ocean Water

Salinity is variable:

Salinity decreases as fresh water enters the ocean:

- Runoff from streams and rivers
- Precipitation
- Melting of glacial ice

Salinity increases as fresh water leaves the ocean:

- Evaporation
- Formation of sea ice

Earth's Fresh Water

Only ~3% of Earth's water is "fresh." Of the 3 %:

~85% is frozen in ice sheets and glaciers

~14% is groundwater

~0.8% is in lakes and reservoirs, soil moisture, and rivers

~0.04% is water vapor

Surface Water

Surface water includes streams, rivers, lakes, and reservoirs.

Infiltration of water is controlled by:

- Intensity and duration of precipitation
- Prior wetness condition of the soil
- Soil type
- Slope of the land
- Nature of the vegetative cover

Surface Water

The land area that contributes water to a stream is called the *drainage basin.*

Drainage basins are separated by drainage divides.

The largest drainage divides are continental divides.

Groundwater

Water beneath the ground exists as groundwater and soil moisture.

Groundwater occurs in the *saturated zone*—water has filled all pore spaces.

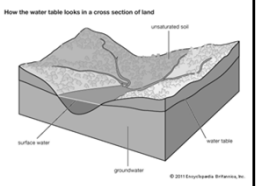
Soil moisture is above the saturated zone in the *unsaturated zone*—pores filled with water and air.

The *water table* is the boundary between these two zones.

Groundwater

The depth of the water table varies with precipitation and climate.

- Zero in marshes and swamps, hundreds of meters in some deserts.
- At perennial lakes and streams, the water table is above the land surface.
- The water table tends to rise and fall with the surface topography.



Groundwater

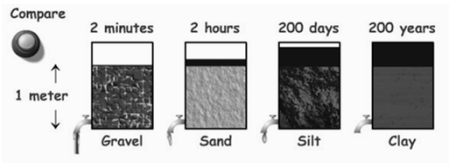
Factors that influence storage and movement of groundwater:

- *Porosity*: ratio of open space in soil, sediment, or rock to total volume of solids plus voids—the amount of open space underground.
- Greater porosity equals more potential to store greater amounts of groundwater.
- Particle size, shape, and sorting influence porosity.
  - Soil with rounded particles of similar size has higher porosity than soil with various sizes.

Groundwater

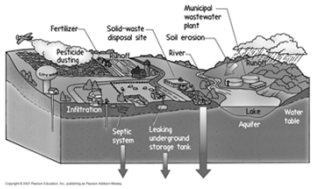
Permeability is the degree to which groundwater <u>can</u> flow through a porous material—higher permeability, greater potential for fluid flow.

- Sediment packing and connectedness of pores influences permeability



Groundwater

Aquifers are reservoirs of groundwater.
Aquifers generally have high porosity and high permeability.
Aquifers underlie the land surface in many areas; they are a vital source of fresh water.
It is important to keep this vital source of fresh water clean and contaminant free.



Water Pollution

- Water pollution is chemical, physical, or biological material that harms organisms, depending on the water.

TABLE 24.5 SOURCES OF WATER POLLUTION

Point Pollution
- Wastewater treatment plants
- Landfills
- Underground storage tanks, including gasoline tanks
- Septic tank systems

Nonpoint Pollution
- Salt applied to roadways
- Runoff from suburban and urban streets (contains litter, dog waste, oil, gasoline, etc.)
- Fertilizer
- Pesticides

Water Pollution

TABLE 24.4 COMMON KINDS OF WATER POLLUTANTS

Organic Chemicals
Fertilizers; pesticides; detergents; plastics; petroleum products, including gasoline and oil

Inorganic Chemicals
Metals; acids; salts

Toxic Chemicals
Chemicals that are poisonous to living things, including heavy metals such as arsenic and mercury; many industrial chemicals; some household chemicals, such as paint thinner and motor oil

Physical Pollutants
Heat; suspended particles, such as soil; litter, including fishing nets and plastic objects such as six-pack rings

Pathogens
Organisms that cause disease, such as bacteria and viruses; pathogens in untreated sewage and animal feces that are washed into the water

Organic Matter
Remains of organisms, including carcasses, feces, and plant material

Glaciers

- There are two types of glaciers: alpine and continental.
- Alpine glaciers are contained in mountain valleys.
- Continental glaciers are vast regions of thick ice—also called "ice sheets."

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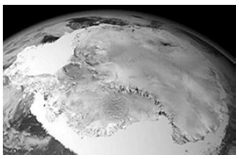

Glaciers

Glaciers move by sliding along downslope over a liquid base.
As they move, they erode the landscape.