

Chapter 15

Geology

**Processes, Hazards, and
Soils**

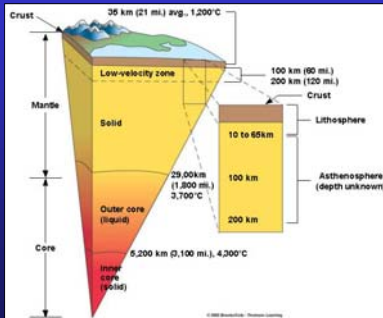
Key Concepts

- Internal geologic processes
- External geologic processes
- Minerals, rocks, and the rock cycle
- Earthquakes and volcanoes
- Soil structure and formation
- Soil conservation

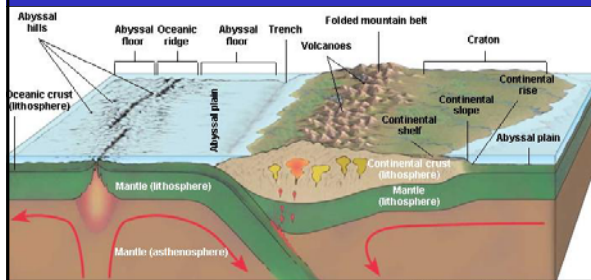
Internal Geologic Processes

- Structure of the Earth
- Features of the Crust
- Plate Tectonics

Structure of the Earth



Features of the Crust



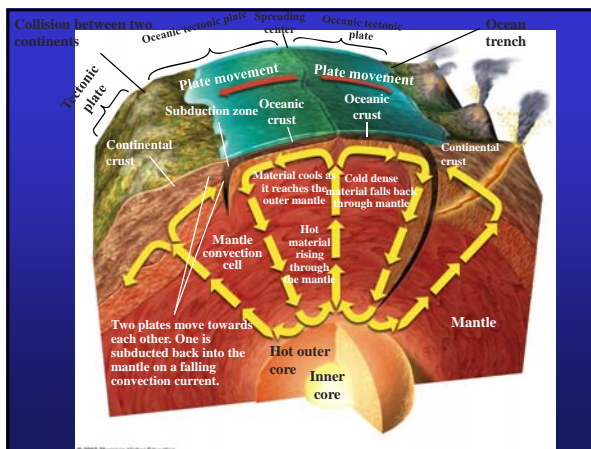


Plate Tectonics

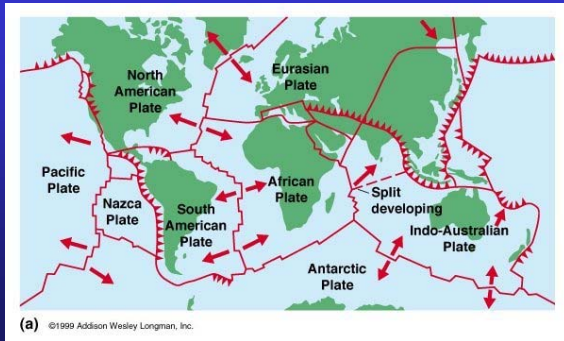


Plate Tectonics

- Divergent boundary

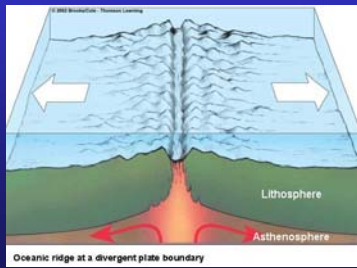


Plate Tectonics

- Convergent boundary
– Subduction zone

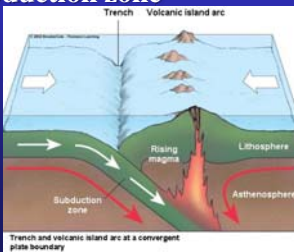


Plate Tectonics

- Transform fault

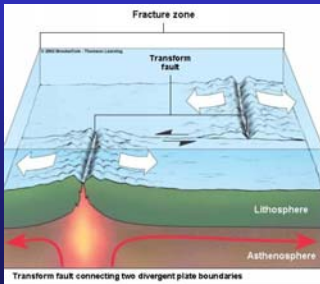
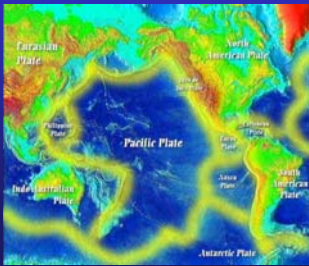
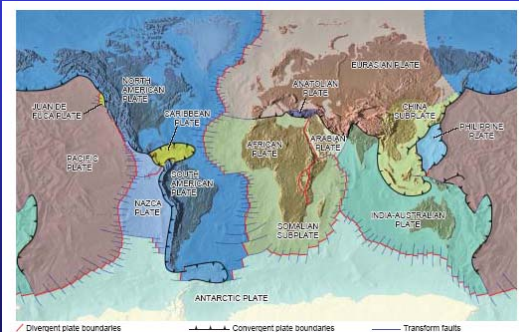


Plate Tectonics

- Ring of Fire



The Earth's Major Tectonic Plates

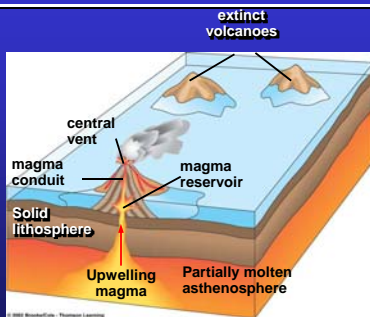


GEOLOGIC PROCESSES



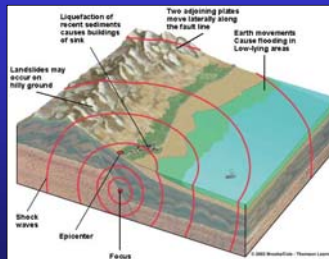
- The San Andreas Fault is an example of a transform fault.

Volcanic Eruptions

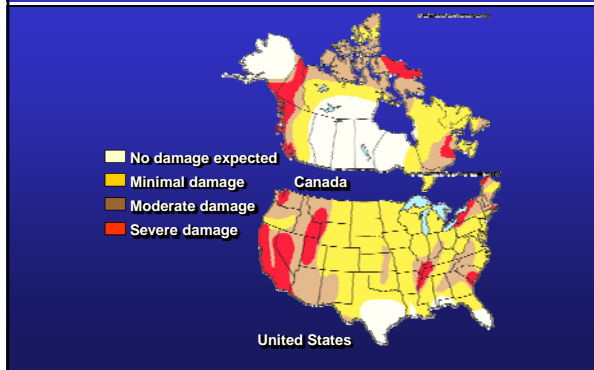


Earthquakes

- Features
- Magnitude
- Aftershocks
- Primary effects
- Secondary effects



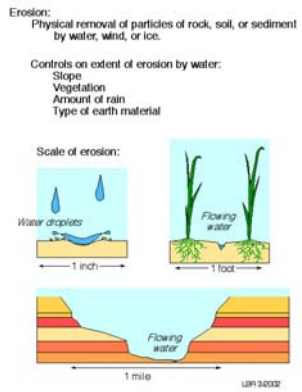
Expected Earthquake Damage



External Earth Processes

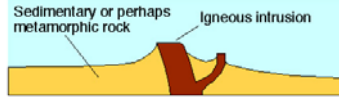
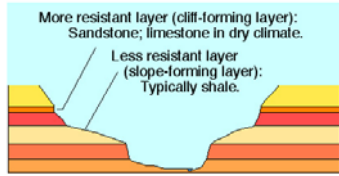
- Erosion
- Mechanical weathering
- Frost wedging
- Chemical weathering

Erosion



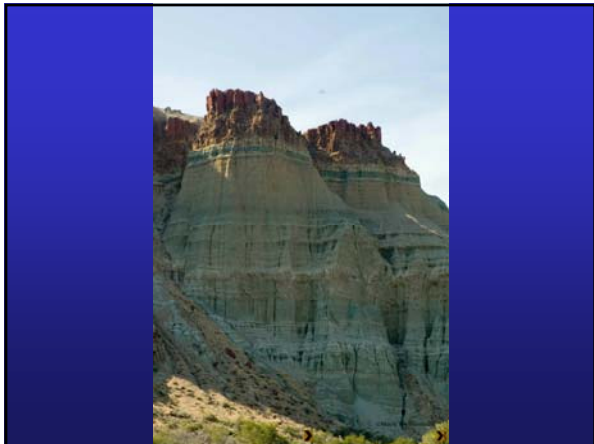
Erosion

Differential Erosion:
Different rock types erode to give different slopes.



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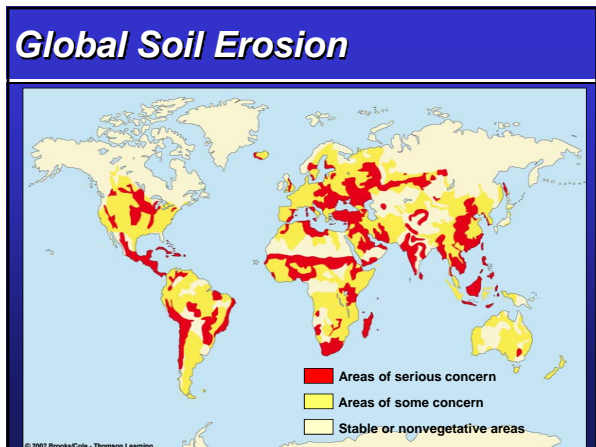


Erosion

Drainage Pattern	Underlying Geology
	Dendritic Igneous rocks, metamorphic rocks, or flat-lying sedimentary rocks, with little regional slope.
	Parallel Moderate to steep regional slope (to SW or SE) or parallel elongate landforms
	Trellis Dipping or folded sedimentary rocks, or parallel fractures
	Rectangular Fractures or faults at right angles
	Radial Volcano or dome
	Contorted Complexly deformed and intruded metamorphic and igneous rocks

after Howard, A.D., 1967, Drainage analysis in geologic interpretation, American Association of Petroleum Geologists Bulletin v. 51, p. 5245-5278, as summarized in Ritter, D.F., 1976, Geomorphology

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Soils: Erosion

➤ **Sheet erosion**

➤ **Rill erosion**

➤ **Gully erosion**

Sheet Erosion



Sheet Erosion



Rill Erosion



Gully Erosion




Mechanical Weathering

Weathering:
Breakdown of pre-existing minerals at or near Earth surface

Conditions at Earth's surface:
Low temperature
Low pressure
Continuously much water
Dilute water
Acidic water (pH = 3 - 6)
Life present
Abundant O₂

Conditions at depth in Earth (where most rocks form):
High temperature
High pressure
Relatively little water
Saline water (water with high concentrations of dissolved solids)
Neutral to alkaline water (pH = 8 - 12)
No known life
Little O₂

Processes in weathering:
Mechanical weathering - Breakage of rock into smaller pieces
Chemical weathering - Removal of chemical constituents from rock; Generation of new minerals



Mechanical Weathering

Processes:

1. Exfoliation (horizontal fracturing due to release of pressure)
2. Freeze-thaw (breakage as ice freezes in cracks)
3. Root wedging (breakage as roots push into cracks)

Results:

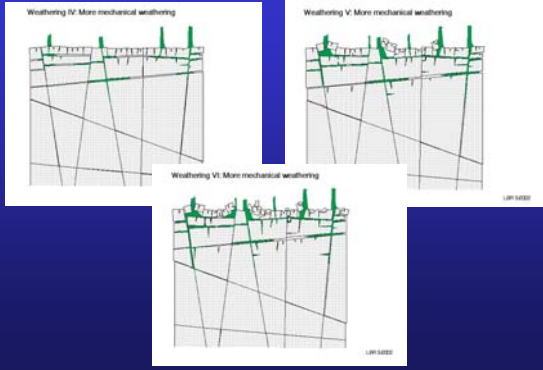
1. Smaller pieces of rock
2. Increased surface area
3. Conduits for water movement

These can be eroded.

These promote chemical weathering.

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Mechanical Weathering



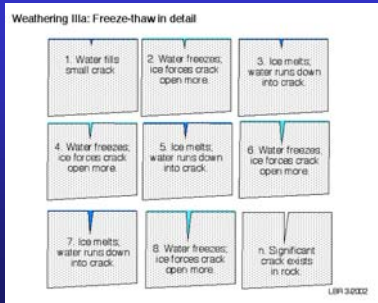
Mechanical Weathering



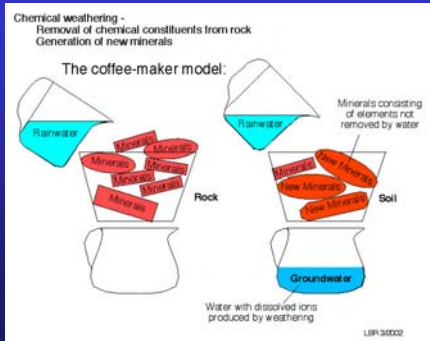
Mechanical Weathering



Frost Wedging

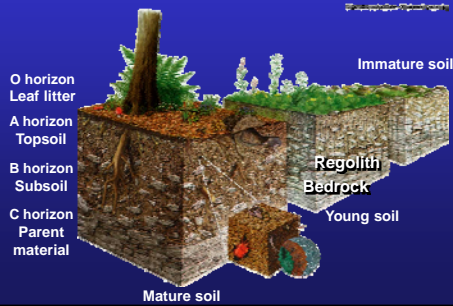


Chemical Weathering



Soils: Formation

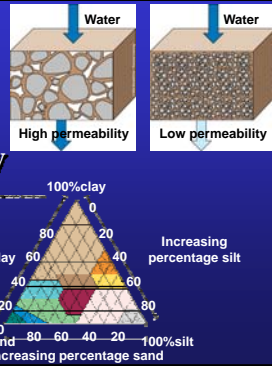
➤ Soil horizons ➤ Soil profile ➤ Humus



Soil Properties

Fig. 10-17 p. 217

- Infiltration
- Leaching
- Porosity/permeability
- Texture
- Structure
- pH

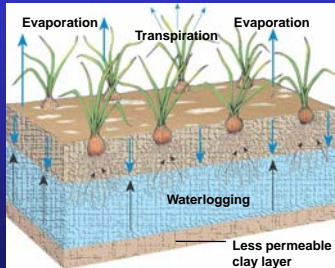


Soil Characteristics

Texture	Nutrient Capacity	Infiltration	Water-Holding Capacity	Aeration	Tilth
Clay	Good	Poor	Good	Poor	Poor
Silt	Medium	Medium	Medium	Medium	Medium
Sand	Poor	Good	Poor	Good	Good
Loam	Medium	Medium	Medium	Medium	Medium

Soils: Degradation

- Desertification
- Salinization
- Waterlogging



Minerals and Rocks

- Mineral (diamond, bauxite)

Rock Types

- Igneous (granite, lava)
- Sedimentary (limestone, sandstone)
- Metamorphic (marble, slate)

Solutions: Soil Conservation

- Conventional-tillage
- Conservation tillage
- Cropping methods
- Windbreaks
- Land Classification

Conventional Tillage

- Plowing the soil in a normal manner
 - The soil is churned up, allowing for the possibility of erosion
 - The planting surface is then smoothed over

Conservation Tillage

- Crops are planted with as little soil disturbance as possible.
- This prevents or lessens the amount of possible erosion.
- Also lower labor costs and energy savings.

Cropping Methods

- Contour Farming
- Strip Cropping
- Terracing

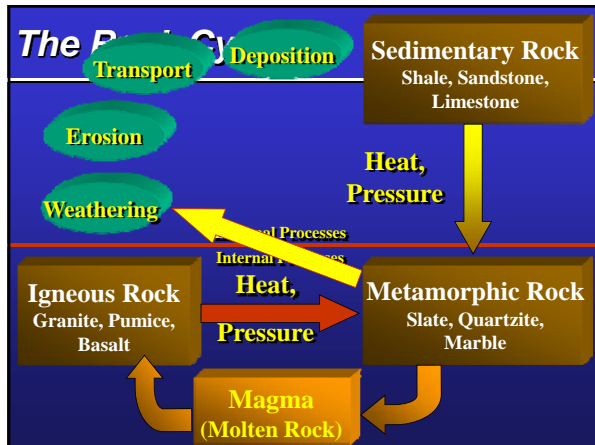


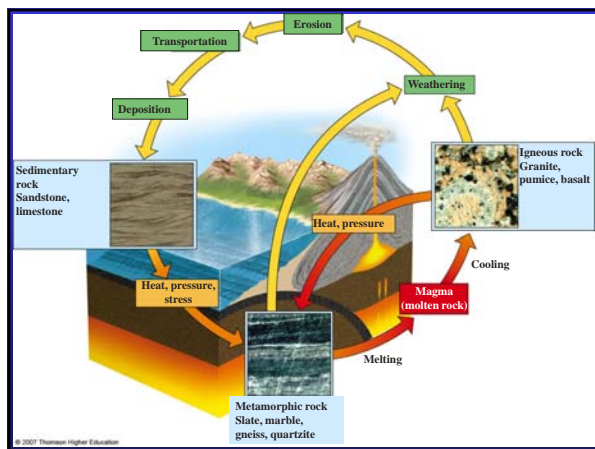
Windbreaks



Soil Restoration

- Organic fertilizer
- Animal manure
- Green manure
- Compost
- Crop rotation
- Commercial inorganic fertilizer





ENVIRONMENTAL EFFECTS OF USING MINERAL RESOURCES



- The extraction, processing, and use of mineral resources has a large environmental impact.



ENVIRONMENTAL EFFECTS OF USING MINERAL RESOURCES

- Minerals are removed through a variety of methods that vary widely in their costs, safety factors, and levels of environmental harm.
- A variety of methods are used based on mineral depth.
 - *Surface mining*: shallow deposits are removed.
 - *Subsurface mining*: deep deposits are removed.

Open-pit Mining



- Machines dig holes and remove ores, sand, gravel, and stone.
- Toxic groundwater can accumulate at the bottom.

Area Strip Mining

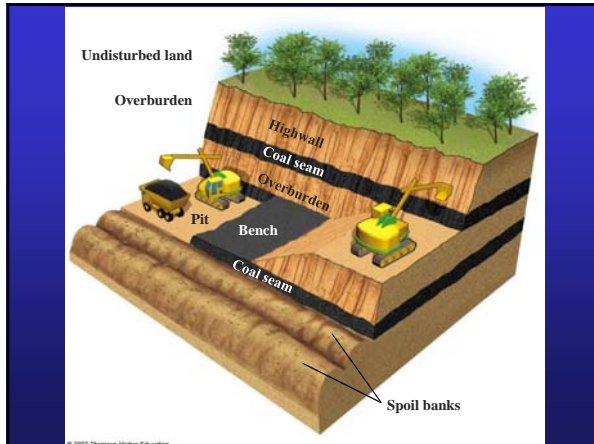


- Earth movers strips away overburden, and giant shovels removes mineral deposit.
- Often leaves highly erodible hills of rubble called *spoil banks*.

Contour Strip Mining



- Used on hilly or mountainous terrain.
- Unless the land is restored, a wall of dirt is left in front of a highly erodible bank called a *highwall*.



Mountaintop Removal



- Machinery removes the tops of mountains to expose coal.
- The resulting waste rock and dirt are dumped into the streams and valleys below.

Mining Impacts

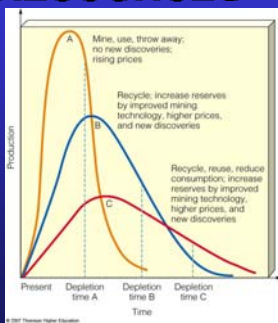


- Metal ores are smelted or treated with (potentially toxic) chemicals to extract the desired metal.

SUPPLIES OF MINERAL RESOURCES

- The future supply of a resource depends on its affordable supply and how rapidly that supply is used.
- A rising price for a scarce mineral resource can increase supplies and encourage more efficient use.

SUPPLIES OF MINERAL RESOURCES



- Depletion curves for a renewable resource using three sets of assumptions.
 - Dashed vertical lines represent times when 80% depletion occurs.

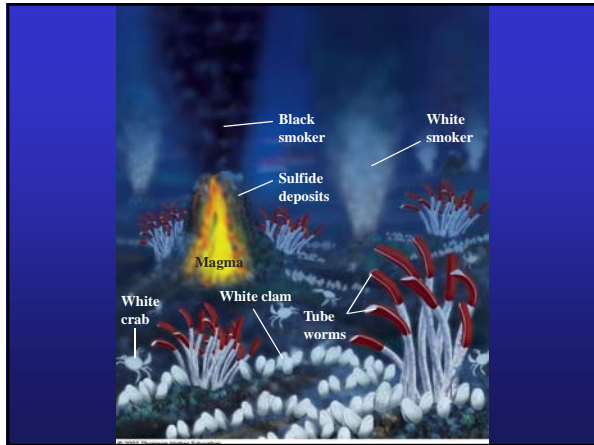
SUPPLIES OF MINERAL RESOURCES

- New technologies can increase the mining of low-grade ores at affordable prices, but harmful environmental effects can limit this approach.
- Most minerals in seawater and on the deep ocean floor cost too much to extract, and there are squabbles over who owns them.

Getting More Minerals from the Ocean



- Hydrothermal deposits form when mineral-rich superheated water shoots out of vents in solidified magma on the ocean floor.



USING MINERAL RESOURCES MORE SUSTAINABLY

- Scientists and engineers are developing new types of materials as substitutes for many metals.
- Recycling valuable and scarce metals saves money and has a lower environmental impact than mining and extracting them from their ores.

Solutions

Sustainable Use of Nonrenewable Minerals

- Do not waste mineral resources.
- Recycle and reuse 60–80% of mineral resources.
- Include the harmful environmental costs of mining and processing minerals in the prices of items (full-cost pricing).
- Reduce subsidies for mining mineral resources.
- Increase subsidies for recycling, reuse, and finding less environmentally harmful substitutes.
- Redesign manufacturing processes to use less mineral resources and to produce less pollution and waste.
- Have the mineral-based wastes of one manufacturing process become the raw materials for other processes.
- Sell services instead of things.
- Slow population growth.
