

Minerals & Soil Resources

tutorial by Paul Rich

Outline

1. **Geologic Processes**
Earth's structure, plate tectonics
2. **Soil Erosion & Degradation**
causes, desertification, salinization & waterlogging
3. **Soil Conservation**
conservation tillage, practices, maintenance & restoration
4. **Mineral Resources**
what are minerals, finding & removing mineral deposits,
depletion time, distribution
5. **Environmental Effects of Mineral Extraction**
economic depletion, finding more vs. substitutes

1. Geologic Processes

Earth's major geological zones:

core: solid center surrounded by molten layer, mostly iron;

mantle: solid zone with hot, partly molten "plastic" upper layer known as *asthenosphere*; rich in iron, silicon, oxygen, & magnesium;

crust: outermost thin layer, location of mineral resources & soil.

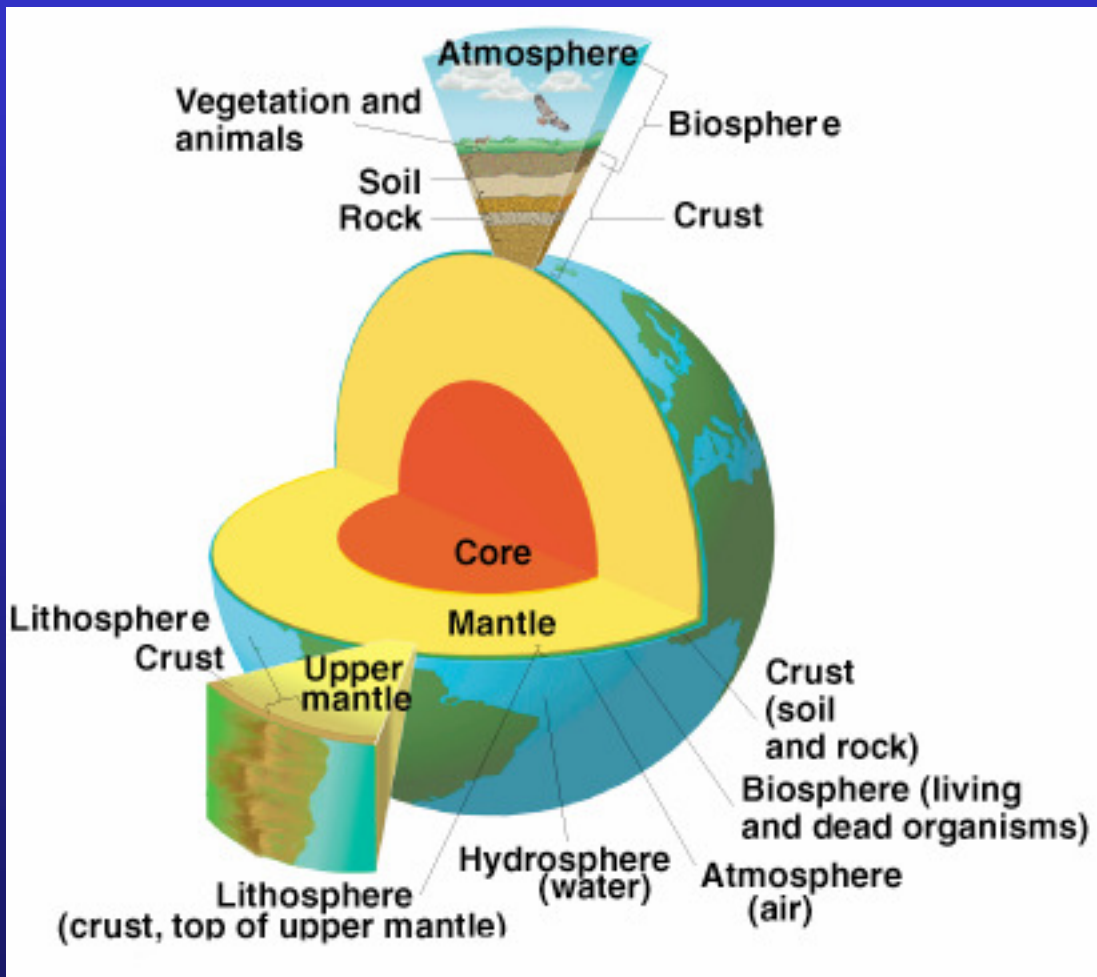
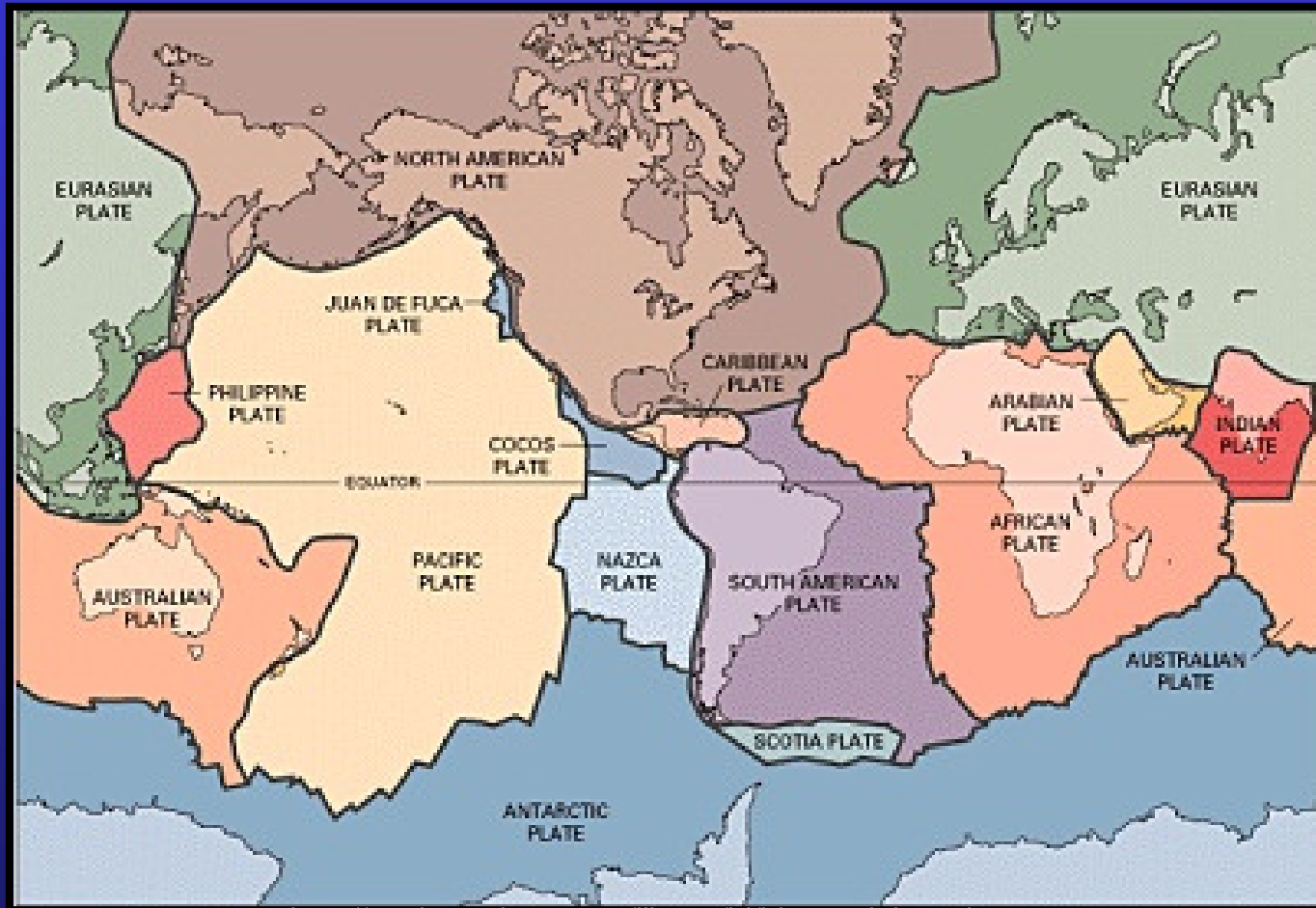


Fig.4-5

Plate Tectonics



•<http://geology.about.com/library/bl/blcrustalplates.htm>

“The Earth's outer layers are organized into about a dozen great pieces, called lithospheric or crustal plates.”

Plate tectonic activity, known also as continental drift, is responsible for the current position of continents.

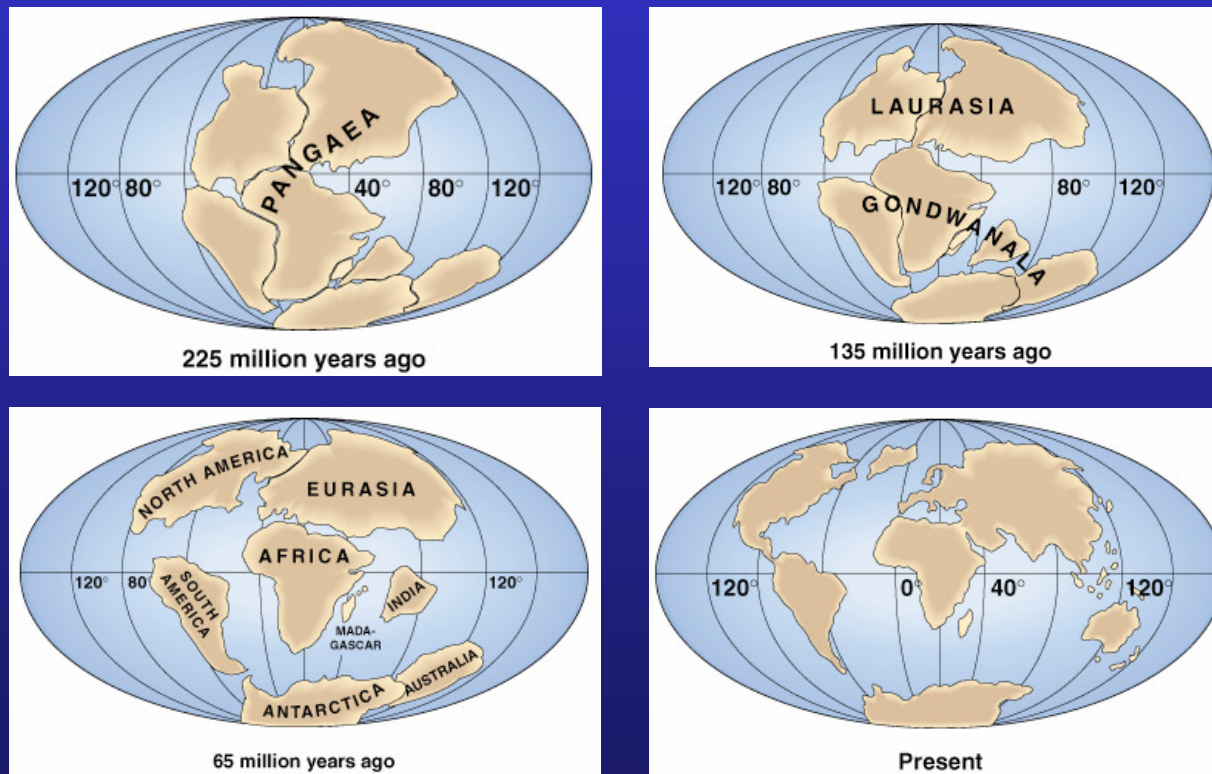


Fig. 6–12

Earthquakes & volcanoes are distributed mostly in bands along the Earth's surface. These bands correspond to tectonic plate boundaries.

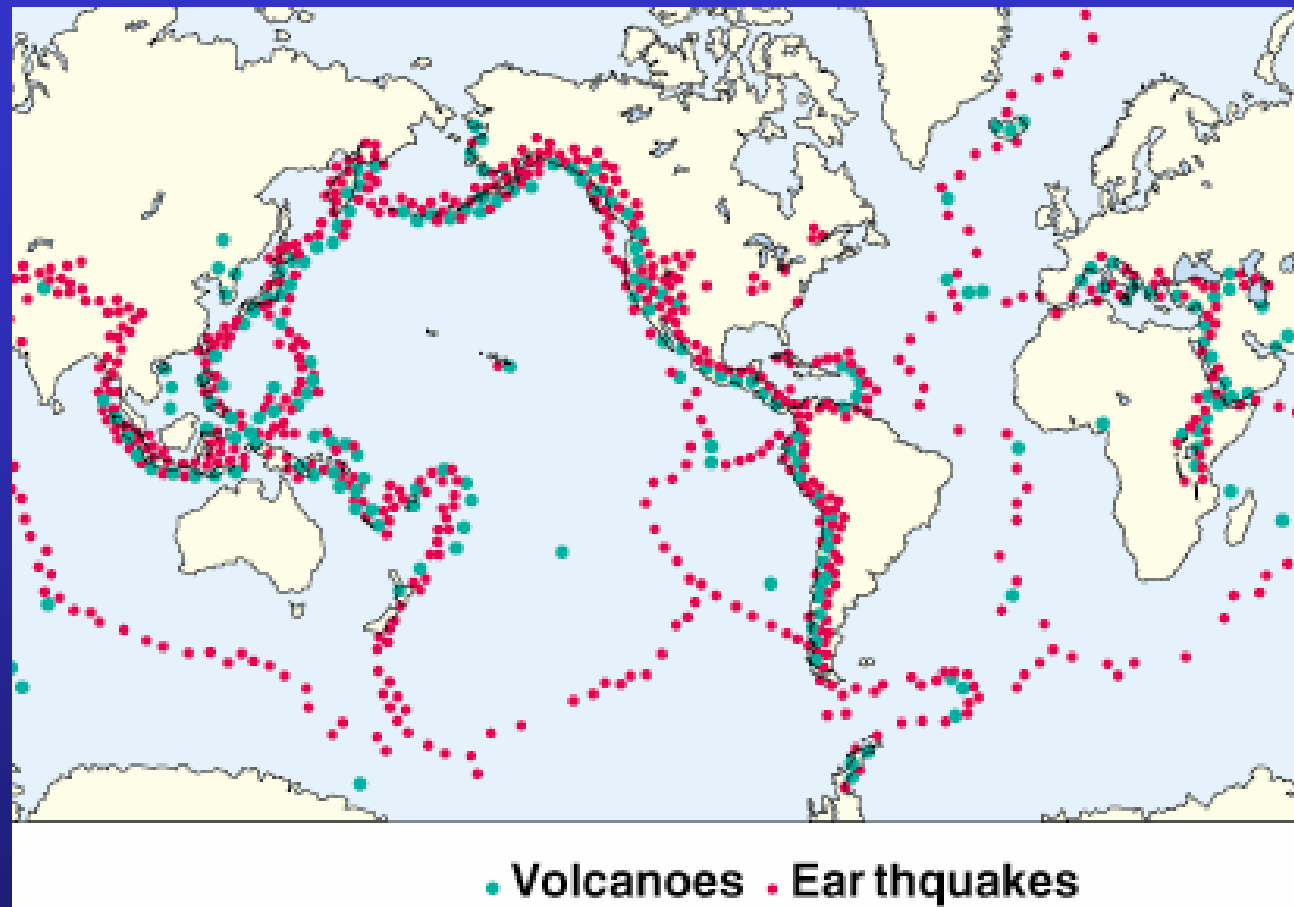
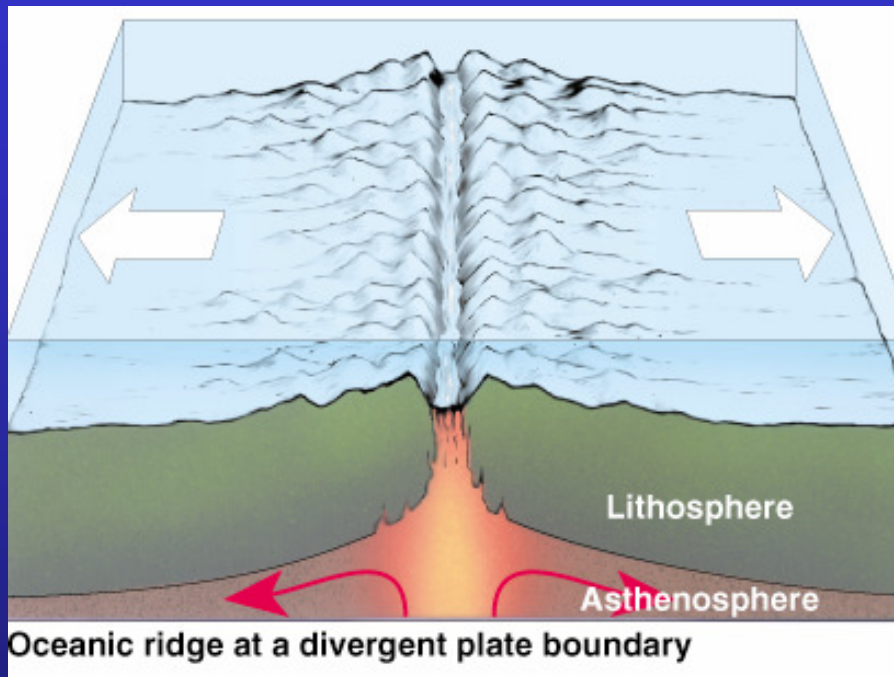


Fig.14-3

Boundaries Between Lithospheric Plates

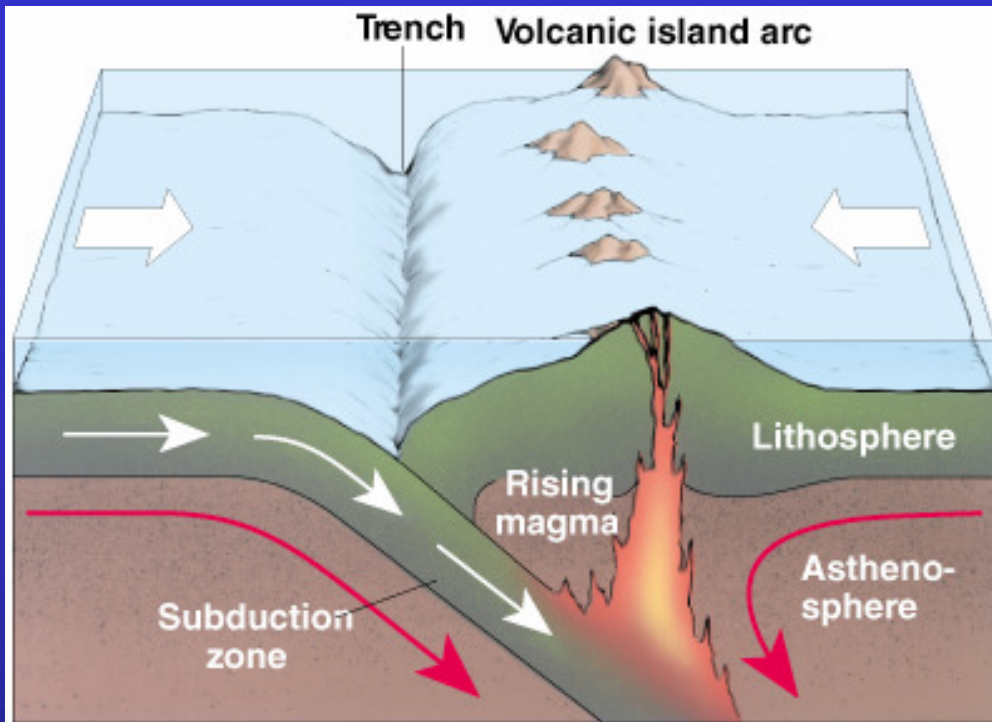
(occur both in oceans and on continents)



•<http://www.pbs.org/wgbh/aso/tryit/tectonics/intro.html>

New crust is formed at divergent plate boundaries.



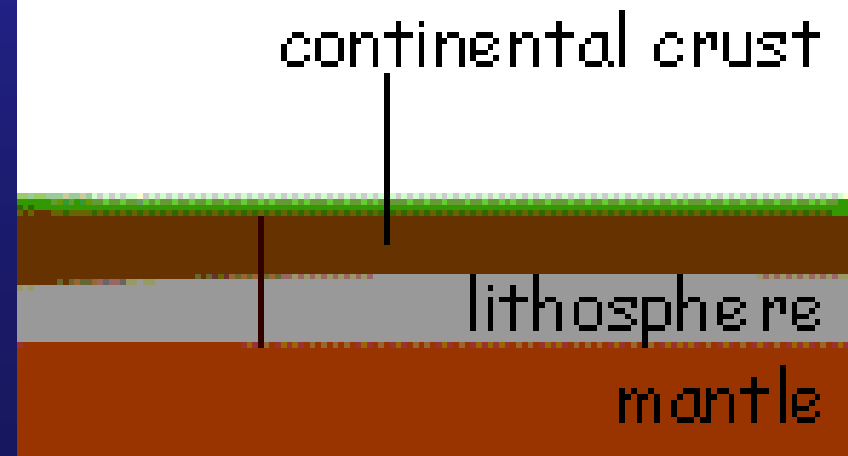


Trench and volcanic island arc at a convergent plate boundary

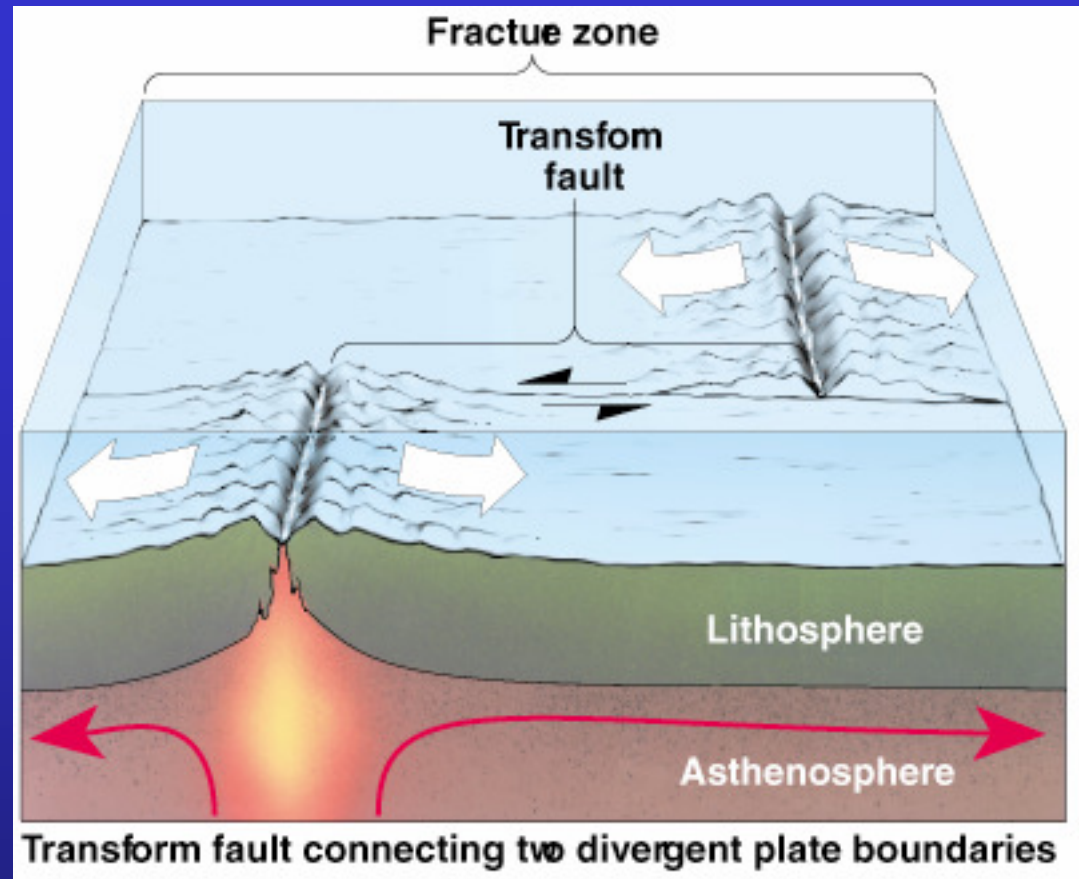
*At convergent plate boundaries, volcanic mountain chains form along **subduction zones**, where crust descends down to the asthenosphere & is melted.*

•<http://www.pbs.org/wgbh/aso/tryit/tectonics/intro.html>

Converging plates of continental crust can form mountain ranges.



Transform faults occur where tectonic plates move in opposite directions. The San Andreas Fault is a large ***transform fault*** along the coast of California.



Geologic Processes

Major geologic processes at Earth's surface:

- **Weathering:** physical & chemical processes in which solid rock exposed at the earth's surface is changed to separate solid particles & dissolved material;

Weathering is responsible for the development of soils.

- **Erosion:** the process by which earth materials are transported from one location & deposited in other locations;

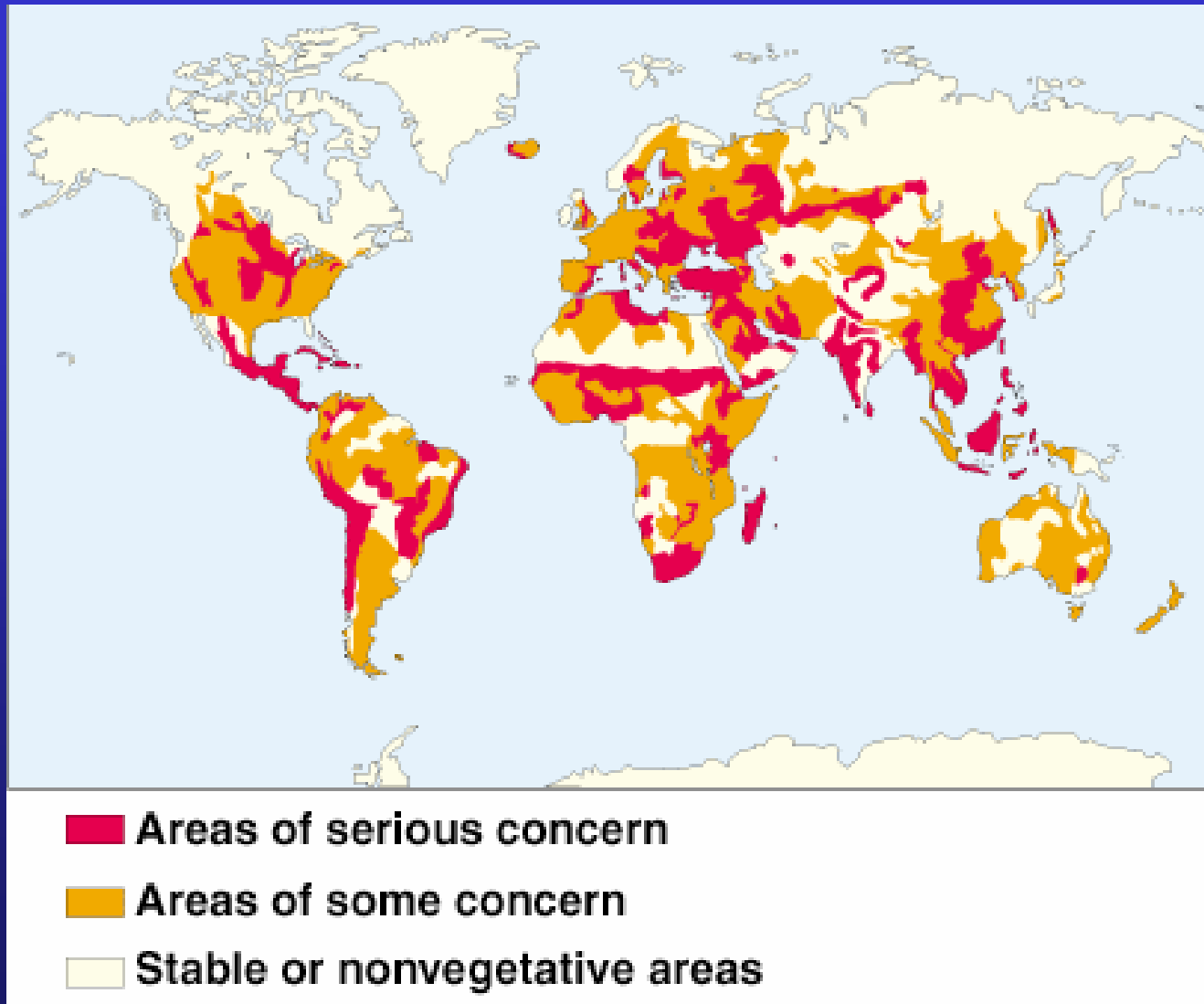
Streams are the most important agent of erosion.

2. Soil Erosion & Degradation

Soil erosion: movement of soil components, especially litter & topsoil, from one place to another.

- losing topsoil makes soil less fertile & less able to hold water;
- while soil is a potentially renewable resource, it takes long periods of time to form topsoil, typically 200–1000 years to form 2.5 centimeters (1 inch) of topsoil;
- topsoil is eroding faster than it forms in about one-third of the world's cropland.

Major areas of the world are threatened by serious soil erosion.



The Dust Bowl of the Great Plains

During the 1930s, a combination of drought & poor soil conservation led to severe wind erosion of topsoil in what is known as the Dust Bowl of the Great Plains.



•<http://www.usd.edu/anth/epa/dust.html>



Video:

http://www.history.com/media.do?action=clip&id=tdih_may11_broadband

Desertification of arid & semiarid lands results when land productive drops markedly.

Causes:

- overgrazing;
- deforestation & devegetation;
- surface mining;
- poor irrigation techniques;
- salt buildup;
- farming on unsuitable terrain;
- soil compaction by farm machinery.

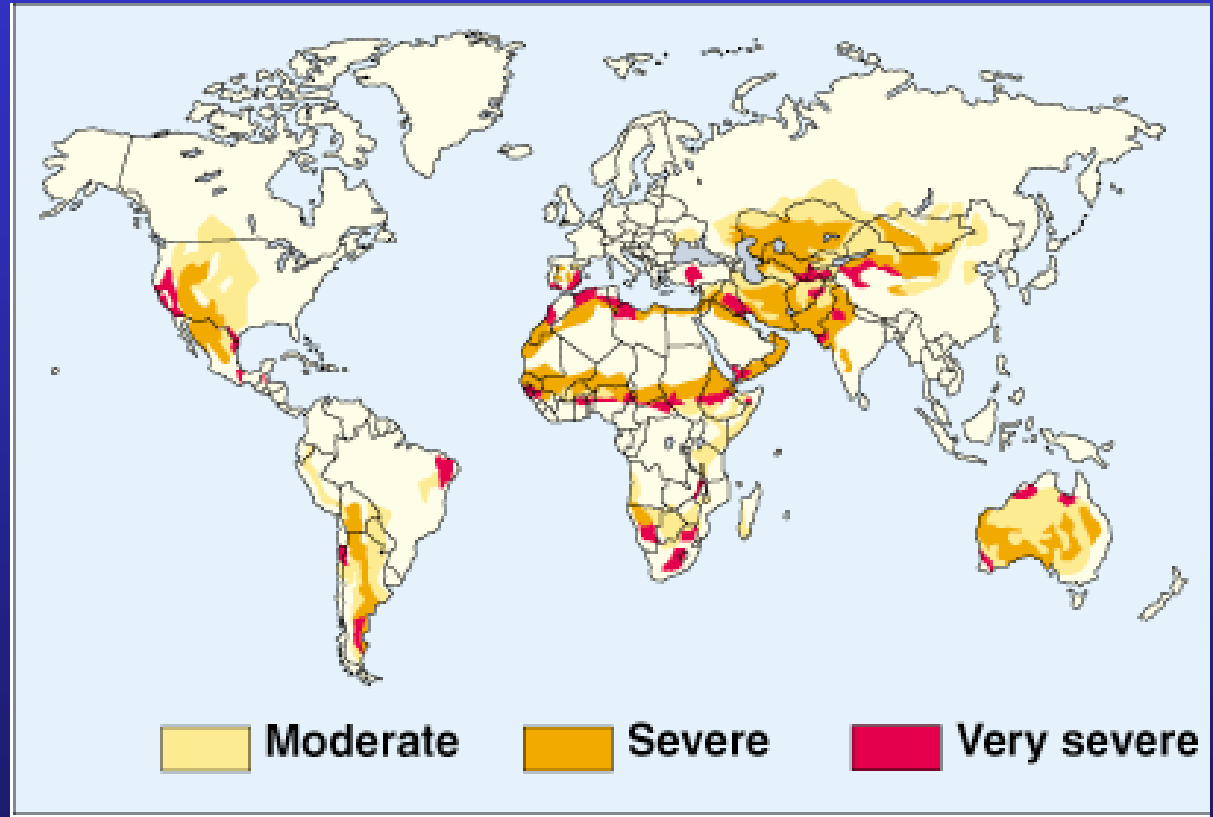


Fig.14–19

Land Video:

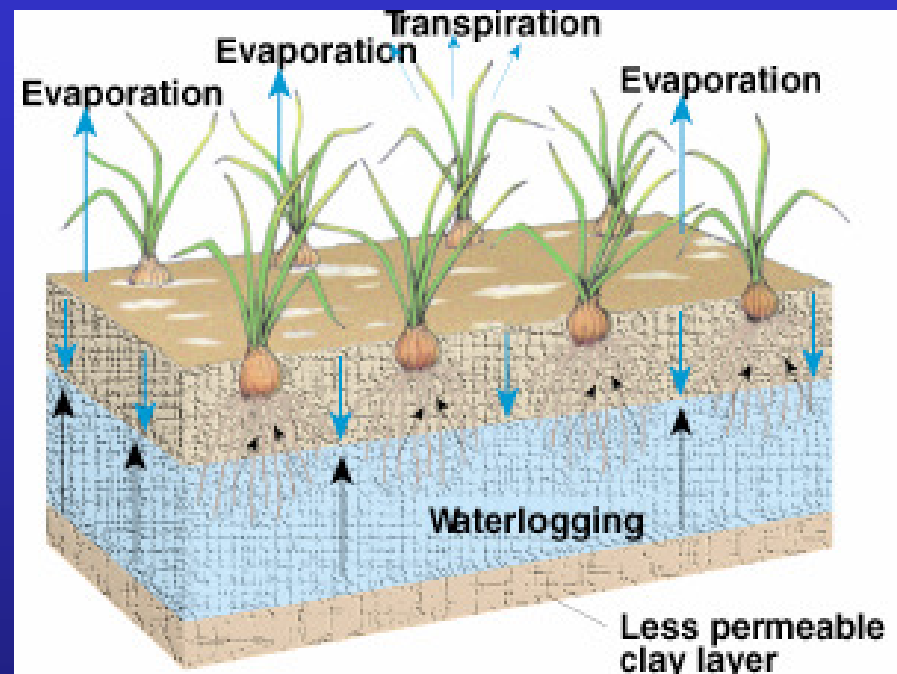
<http://video.nationalgeographic.com/video/player/environment/environmental-threats-environment/state-of-the-earth/land.html>

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Problems with Irrigation

Salinization results in irrigated cropland where salts build up to levels that decrease yields or prevent cultivation.

Waterlogging results when excess irrigation water raises the water table & lowers crop productivity.



Salinization

1. Irrigation water contains small amounts of dissolved salts.
2. Evaporation and transpiration leave salts behind.
3. Salt builds up in soil.

Waterlogging

1. Precipitation and irrigation water percolate downward.
2. Water table rises.

Fig.14-20

3. Soil Conservation

Reducing soil erosion & restoring soil fertility

Soil Conservation Methods:

- Use of **organic fertilizer** (manure, "green manure" = plant matter, & compost) to keep the soil in place and nutrient-rich;
- **Conservation–tillage farming** minimizes soil disturbance by use of special tillers or by no–till methods that inject seeds, fertilizers, & herbicides in unplowed soil;

The farmer on the lead tractor is mowing cotton stalks following harvest while another farmer follows him with a type of planter known as a drill. The drill is planting rye grass into the cotton stalks and other crop residues that have been left from past harvests. These crop residues slowly decompose, helping to protect and build the soil in the field while helping nourish the newly planted seeds. (CTIC/Mitchell)



<http://www2.ctic.purdue.edu/Core4/CT/PhotosGraphics.html>

Pretty, green cotton plants emerge from a field that was previously planted to wheat. The stalks left from the wheat harvest provide the soil in the field with protection against erosion caused by high winds. The old wheat (crop) residues also keep more water on the fields and serve as a natural filter during heavy rains. (CTIC/Mitchell Photo)



<http://www2.ctic.purdue.edu/Core4/CT/PhotosGraphics.html>

- **Contour farming** follows natural land contours;
- **Strip cropping** maintains strips of different vegetation between crops;
- **Crop rotation** (by planting crops that restore nutrients); & decrease in use of inorganic fertilizers all help to restore fertility.



This aerial view of farmland in Wisconsin beautifully indicates the beneficial effects of strip cropping.
(Photo by Erwin Cole, USDA)

• <http://usinfo.state.gov/products/pubs/desertific/experience.htm>

Alley cropping grows crops between rows of trees.



(Photo by Gary Kramer, USDA NRCS)
<http://usinfo.state.gov/products/pubs/desertific/experience.htm>

Terracing protects steep slopes



A Terraced Field in the Mountainous Area of Lagu Nationality, Yunnan Province (<http://www.acca21.org.cn/nrp3-12.html>)

4. Mineral Resources

Mineral resource: a naturally occurring concentration of solid, liquid, or gaseous material in or on Earth's crust that can be processed into useful materials at an affordable cost.

- **Energy resources:** coal, oil, natural gas, uranium, geothermal energy sources;
- **Metallic mineral resources:** iron, copper, aluminum...;
 - **ore** is a metal–yielding material that can be economically extracted;
 - to be profitable, copper must be concentrated 86 times, gold 1,000 times, & mercury 100,000 times the crustal average;
- **Nonmetallic mineral resources:** salt, gypsum, clay, sand, phosphates, water, & soil.

The U.S. Geological Survey (USGS) divides mineral resources into two broad categories:

- **identified resources:** deposits of a particular mineral resource that have known location, quantity, & quality;
- **undiscovered resources:** deposits of a particular mineral resource that are assumed to exist, based on geologic knowledge & theory, but for which specific locations, quantities, & quality are unknown.

Mineral Resources

Reserves are identified resources that can be extracted economically at current prices using current mining technology.

Other resources are identified & undiscovered resources not classified as reserves.

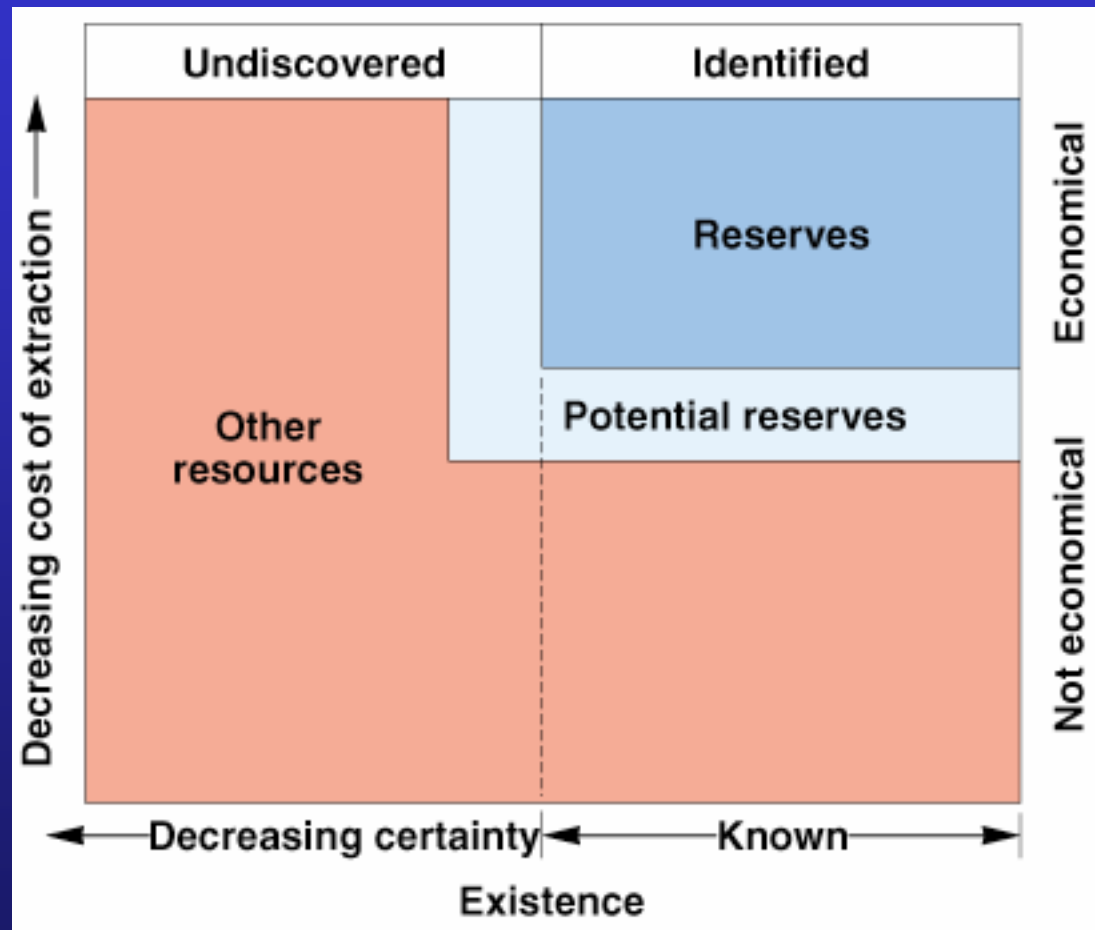


Fig.14-6

Extracting Mineral Resources

- **Strip mining** is surface mining in which the upper layer is removed to get at the desired mineral resource (see example, left);

Video:

http://www.history.com/media.do?action=clip&id=mm_travelogues_wyoming_coalmines_broadband

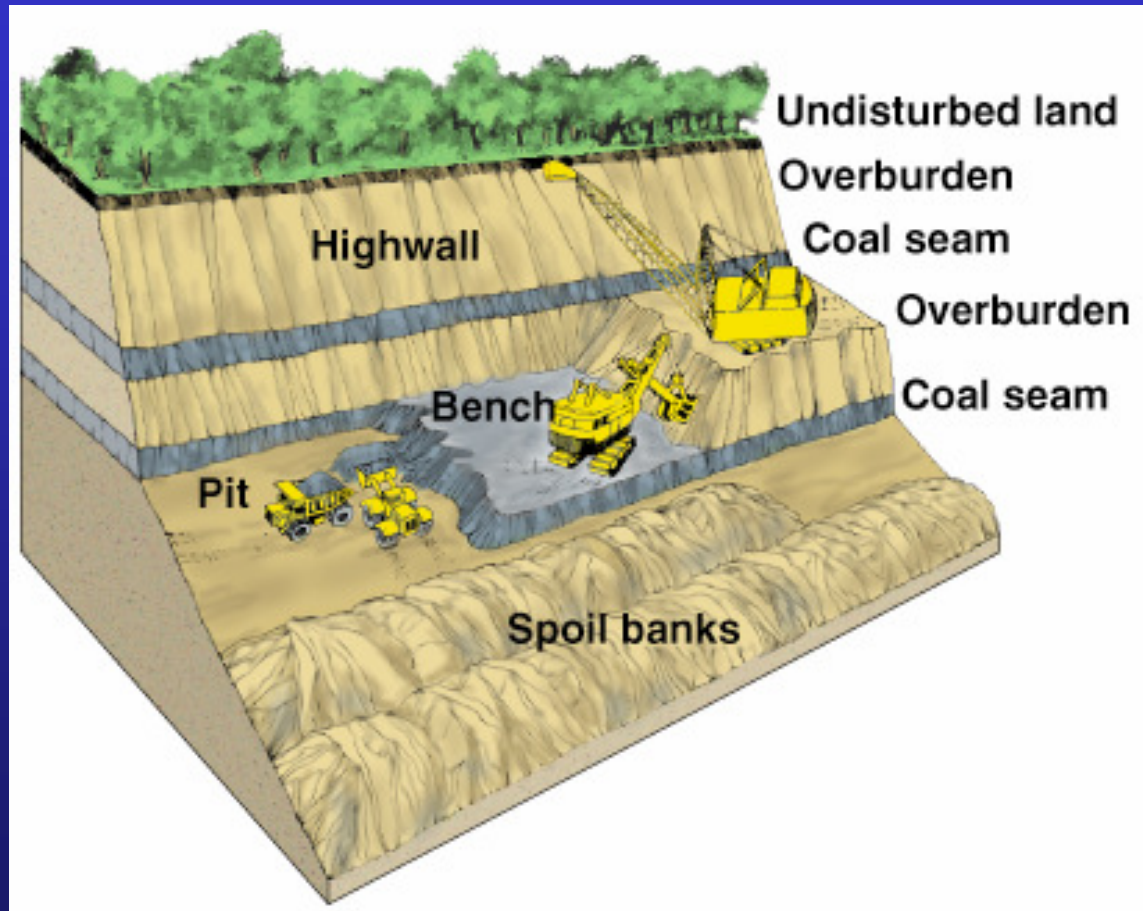
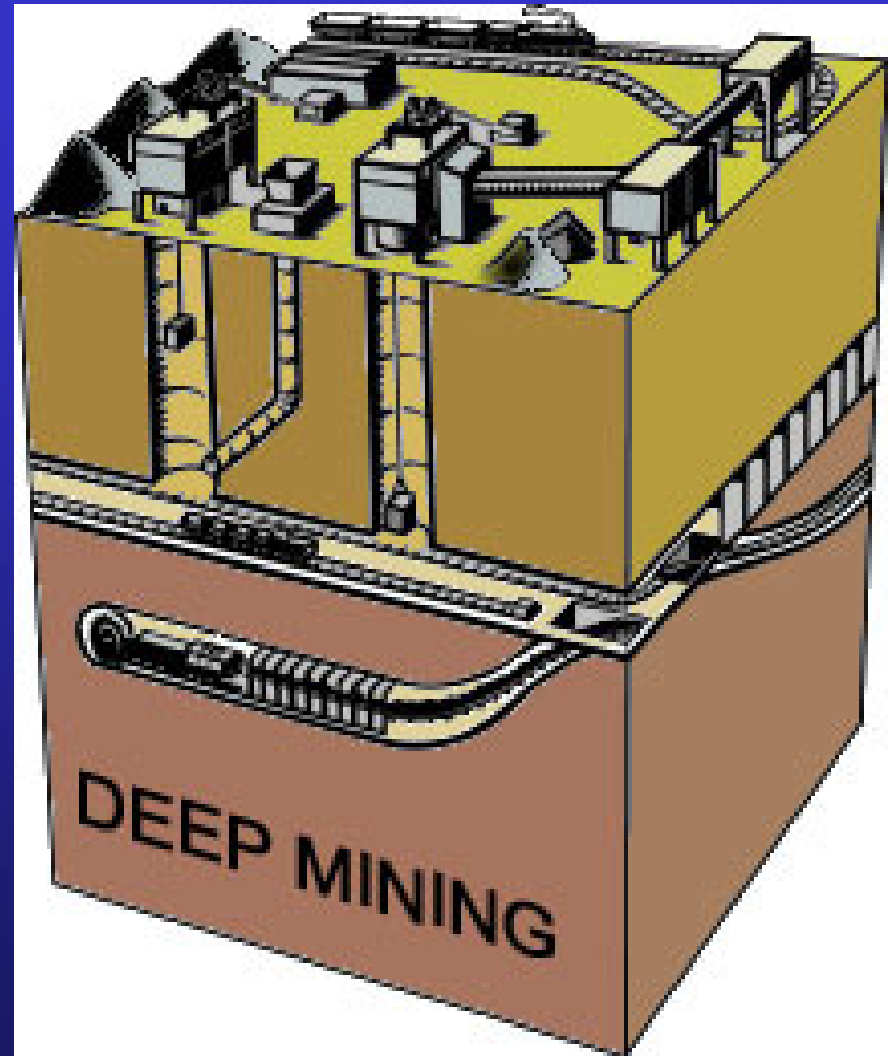


Fig.14-9

- **Subsurface mining** involves use of drill holes or tunnels to extract mineral resources that are too deep to be accessible by surface mining.

Video:

http://www.history.com/media.do?action=clip&id=mm_travelogues_westvirginia_coalmines_broadband



• <http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/coal.html#mining>

Supplies of Mineral Resources

Depletion time is the time it takes to use up a certain proportion (usually 80%) of the reserves of a mineral. The depletion time can be extended by recycling, reuse, & reduction of consumption.

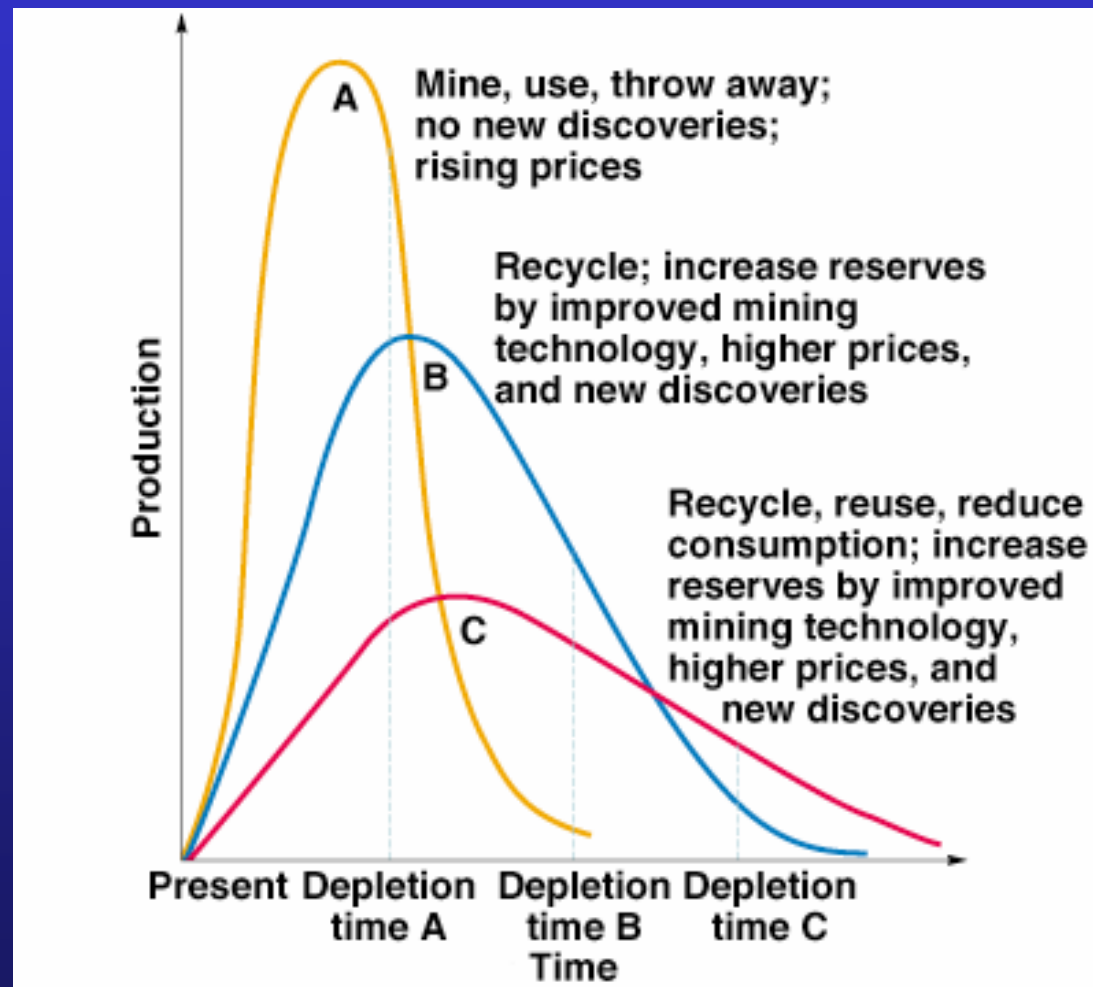


Fig.14-10

Currently the U.S. imports more than 50% of more than 24 of its most important nonfuel minerals.

Some nonfuel minerals for which the U.S. has essentially no reserves:

manganese, cobalt, tantalum, niobium, platinum, chromium, nickel, aluminum, tin, antimony, fluorine, asbestos, vanadium;

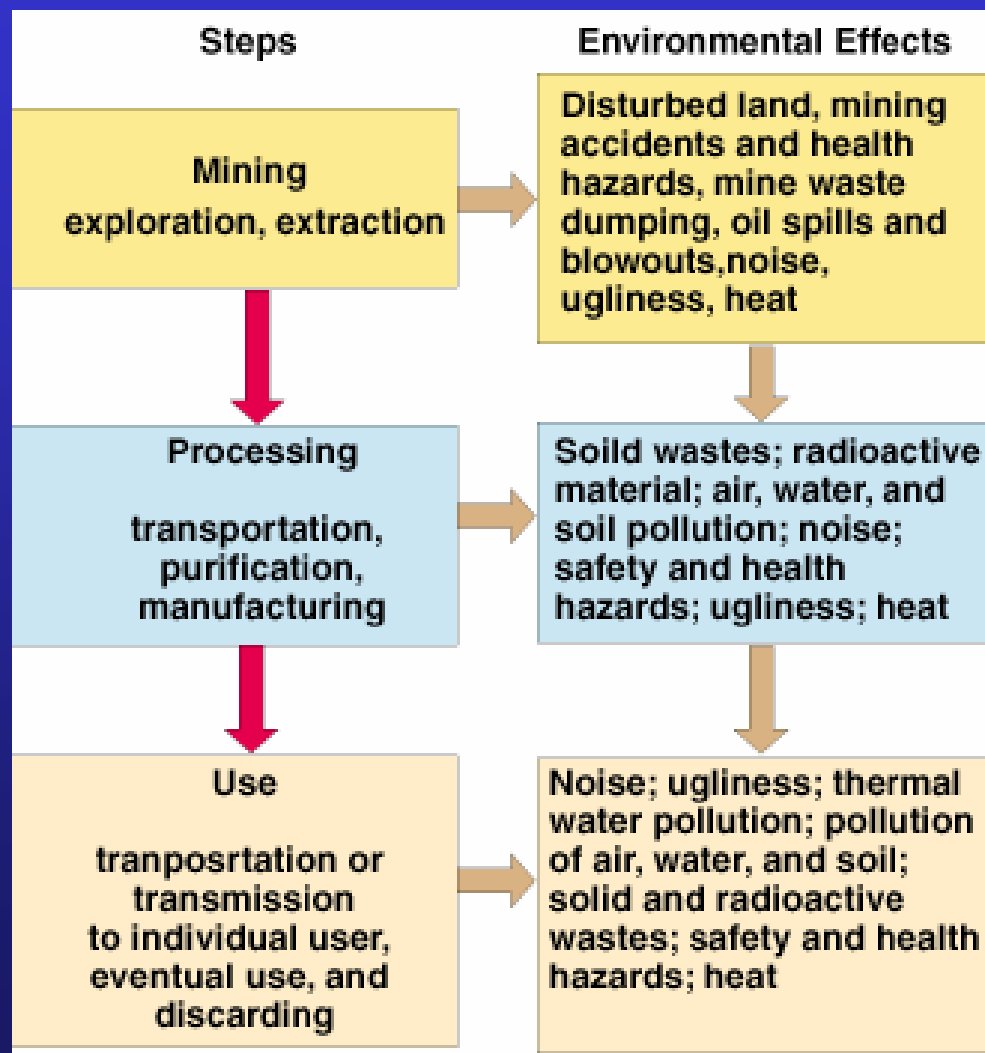
Some nonfuel minerals for which the U.S. has reserve deficiency:

mercury, silver, tungsten, sulfur, zinc, gold, potash;

(See Fig.14–11)

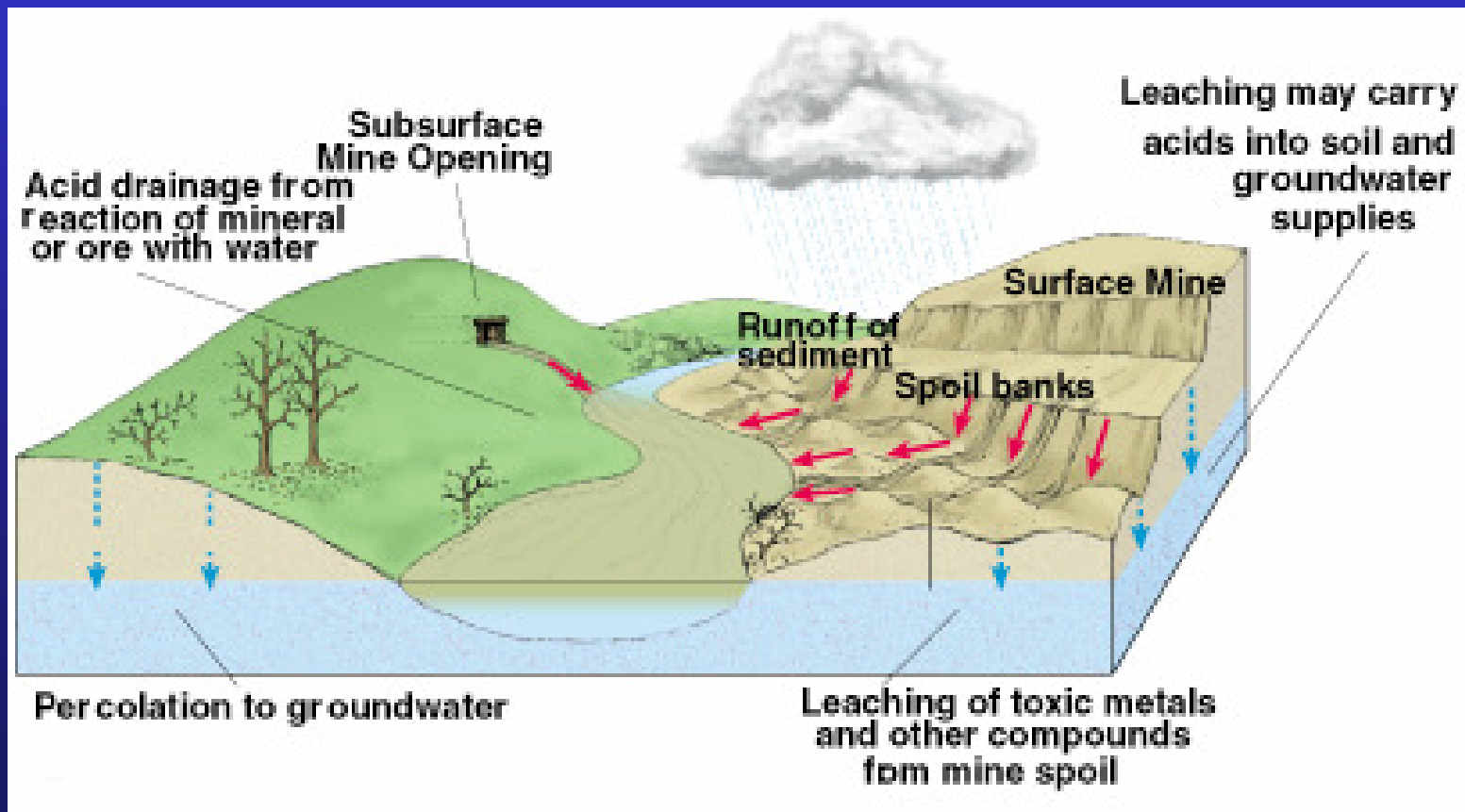
5. Environmental Effects of Mineral Extraction

Some harmful effects of mineral extraction, processing, & use.



Environmental Effects of Mineral Extraction

Pollution & degradation of water quality by runoff of acids & toxic chemicals from surface & subsurface mining.



U.S. 1872 Mining Law

Under an 1872 U.S. mining law, any person or corporation can assume legal ownership of public land (other than wilderness or park) by filing mining claims & paying nominal cost for the land (often \$2.50 to \$5 per acre).

- no provision for reclamation of damaged land;
- environmentalists favor reform of the law to include the following:
 - prohibit buying of public land, but allow leasing;
 - require environmental impact assessment before leasing;
 - set standards for preventing & controlling pollution & environmental degradation;
 - make mining companies legally & financially responsible for environmental cleanup & restoration.