

89.325 – Geology for Engineers

Weathering



WEATHERING

Mechanical "Disintegration"

Breaking a mineral or rock into smaller pieces without changing its chemical makeup



Frost Wedging

Freezing and thawing of water in cracks

Crystal Growth

Salt crystals grow from evaporated salty water

Mechanical Exfoliation

Rocks expand and crack as overlying rocks are removed by erosion

Root Penetration

Powerful tree roots grow in rock fractures

Thermal Expansion and Contraction

Enlargement and reduction of crystal structure in response to heating and cooling

Abrasion

Rocks and minerals collide in a moving current

Chemical "Decomposition"

Changing the chemical composition of rocks and minerals to increase stability



Dissolution

Soluble compounds, such as limestone, are dissolved

Produces caves

Oxidation

Mineral's ions combine with oxygen to form an oxide (common with iron)

Forms rust

Hydrolysis

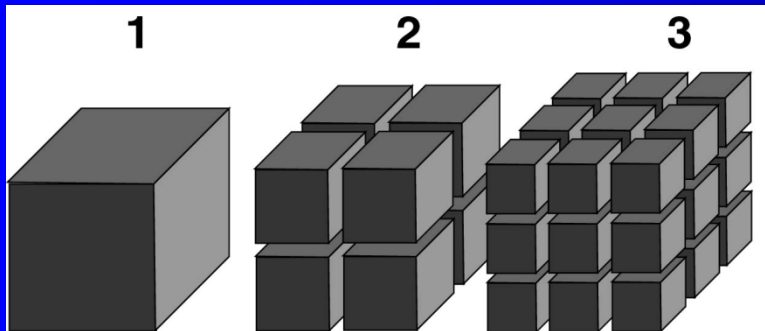
H⁺ ions displace other ions to form a different mineral (common with feldspars)

Forms clay minerals

Weathering – Physical and Chemical

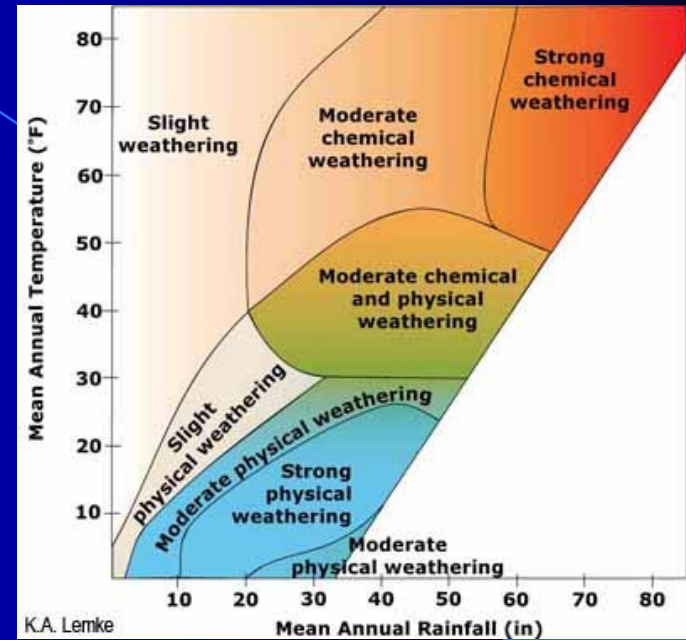
Physical weathering

- Pressure reduction
- Frost wedging
- Salt wedging
- Thermal Stress
- Biological – e.g., plant roots



SA (surface area) = # blocks x SA of each block

1. area of each face = $l \times w = 3'' \times 3'' = 9 \text{ in}^2$
total SA = 6 faces x $9 \text{ in}^2 = 54 \text{ in}^2$
2. area of each face = $l \times w = 1.5'' \times 1.5'' = 2.25 \text{ in}^2$
total SA = 6 faces x 8 blocks x $2.25 \text{ in}^2 = 108 \text{ in}^2$
3. area of each face = $l \times w = 1'' \times 1'' = 1 \text{ in}^2$
total SA = 6 faces x 27 blocks x $1 \text{ in}^2 = 162 \text{ in}^2$

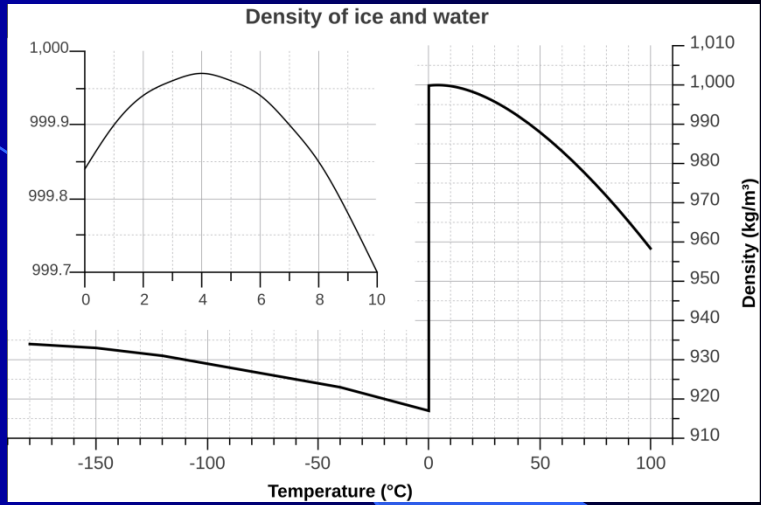
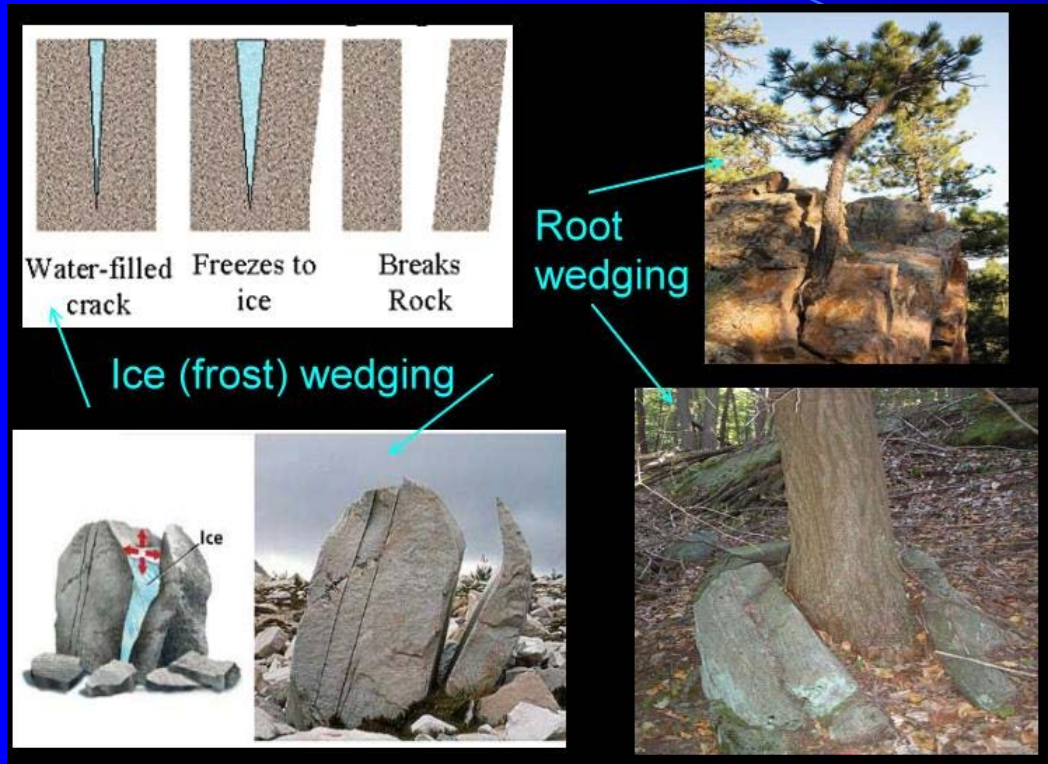


K.A. Lemke

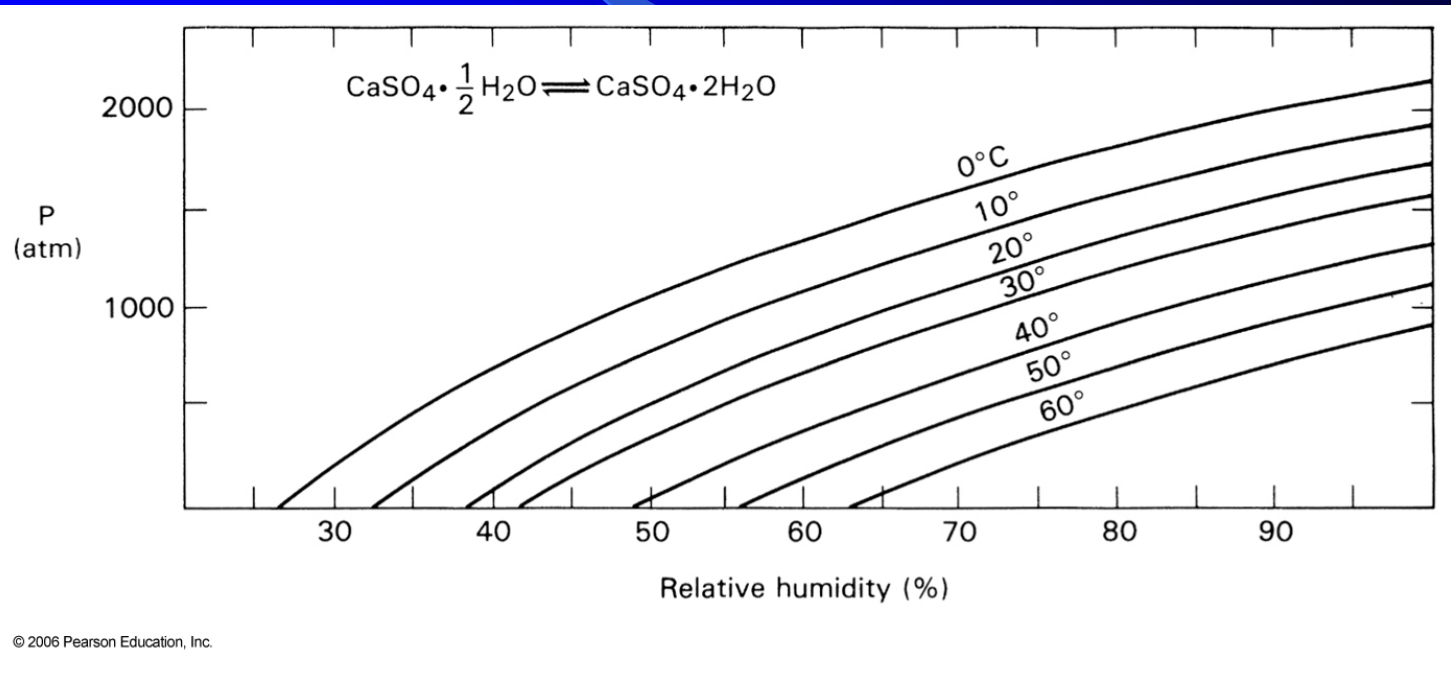
Chemical weathering

- Dissolution and carbonation
- Hydration
- Hydrolysis – silicates and carbonates
- Oxidation
- Biological Weathering

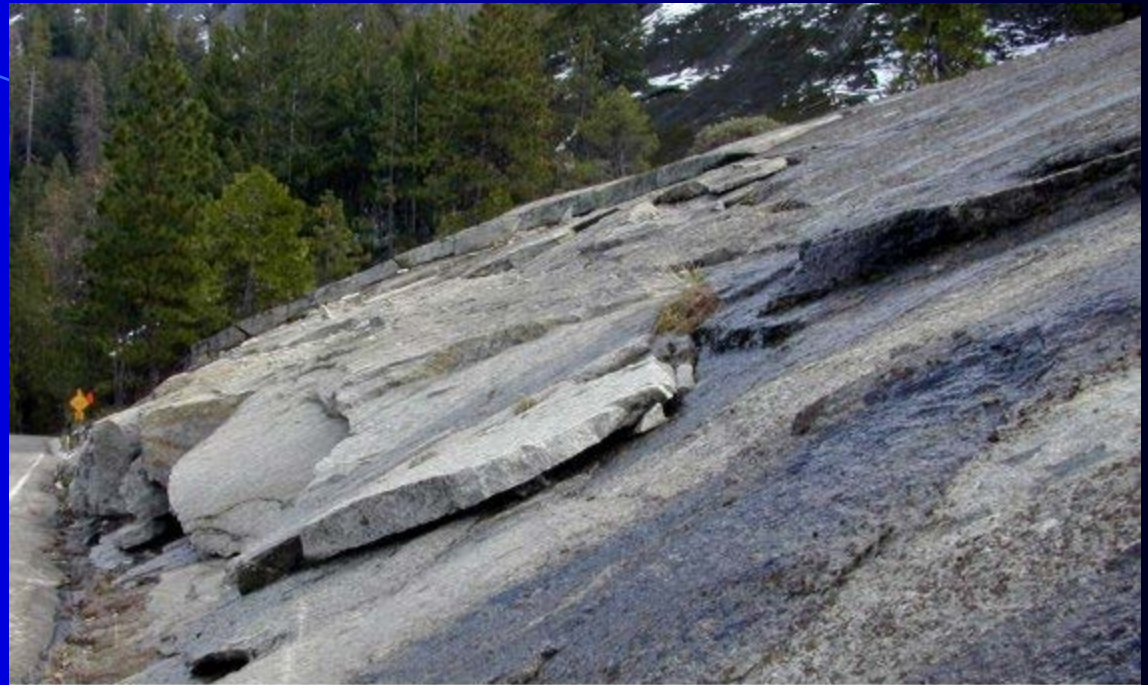
Physical Weathering



Salt weathering



Physical Weathering



Exfoliation slabs, Yosemite National Park, California



Tarbuck & Lutgens

These rocks have been exposed to temperature extremes in desert surroundings which caused them to disintegrate.

Chemical Weathering Reactions

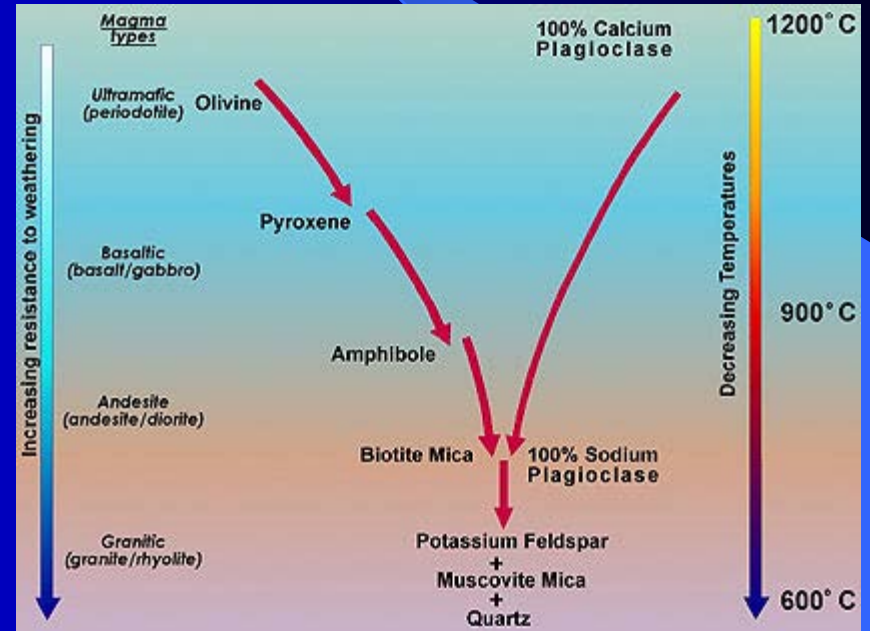
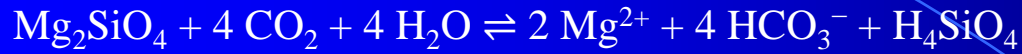
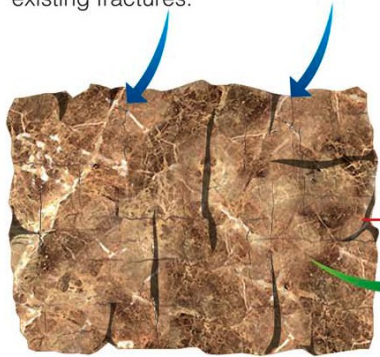


Table 10.1 Relative stabilities of some igneous rock-forming minerals during weathering.

High stability	Quartz
Increasing stability ↑	Muscovite
	K-feldspar
	Biotite Albite
	Hornblende Intermediate plagioclase compositions
	Augite Anorthite
	Low stability

1 Acidified water containing hydrogen ions (H^+) enters feldspar crystal along existing fractures.

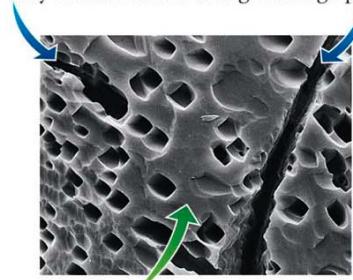


Potassium ion (K^+) leaves in solution.



2 Where potassium has washed away, an insoluble residue of clay remains.

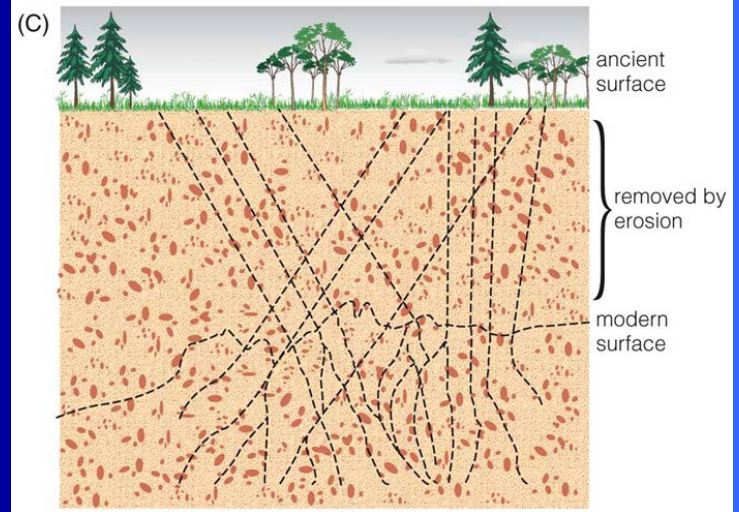
Clay residue forms along cleavage planes



Unaltered feldspar

Unaltered feldspar

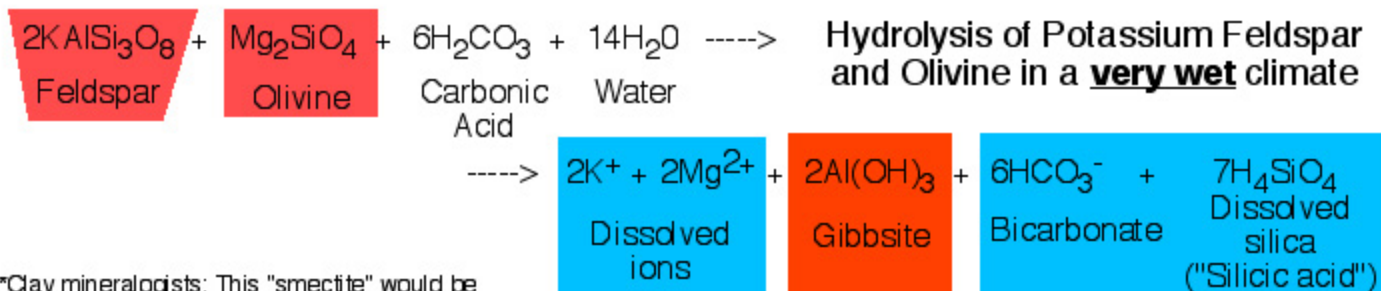
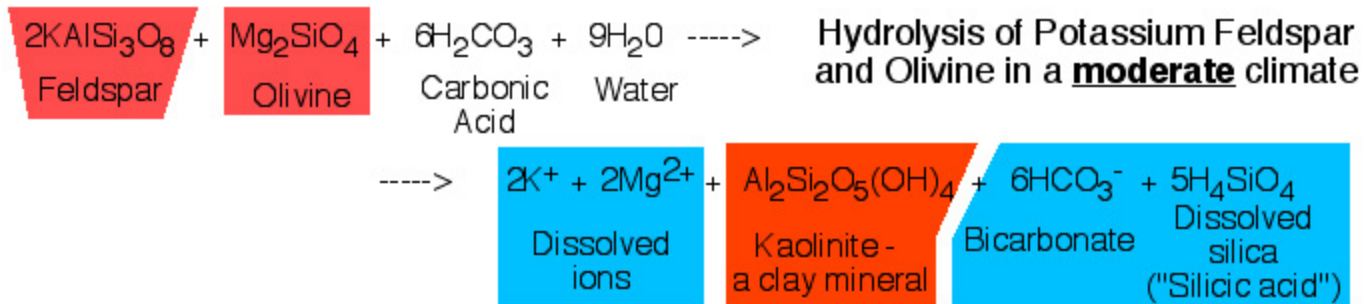
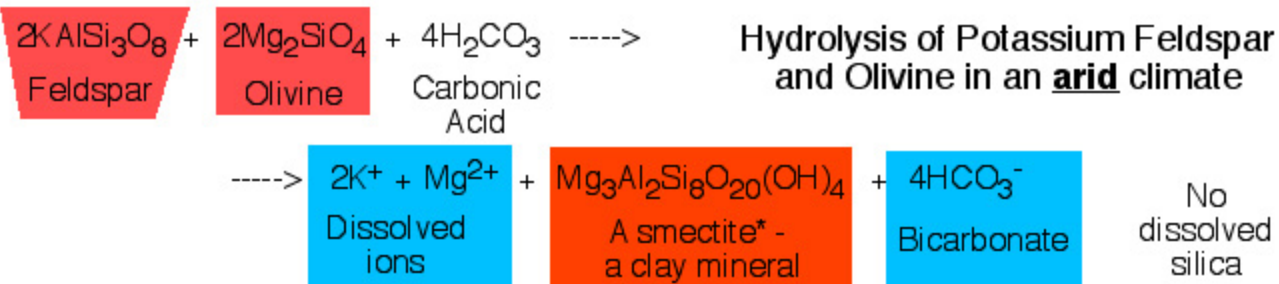
Alteration products (clay)



ancient surface

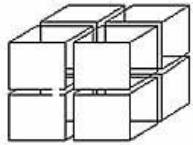
removed by erosion

modern surface

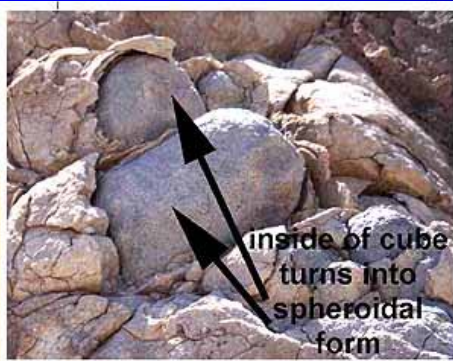
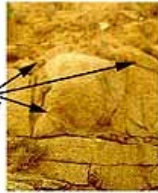


*Clay mineralogists: This "smectite" would be something like a dehydrated wierd beidellite. Leave me alone - this is for introductory students in a general class!

Start with joints on all sides of cube-ish shaped blocks



Corners weather first, giving sphere shape



inside of cube turns into spheroidal form

Spheroidal weathering



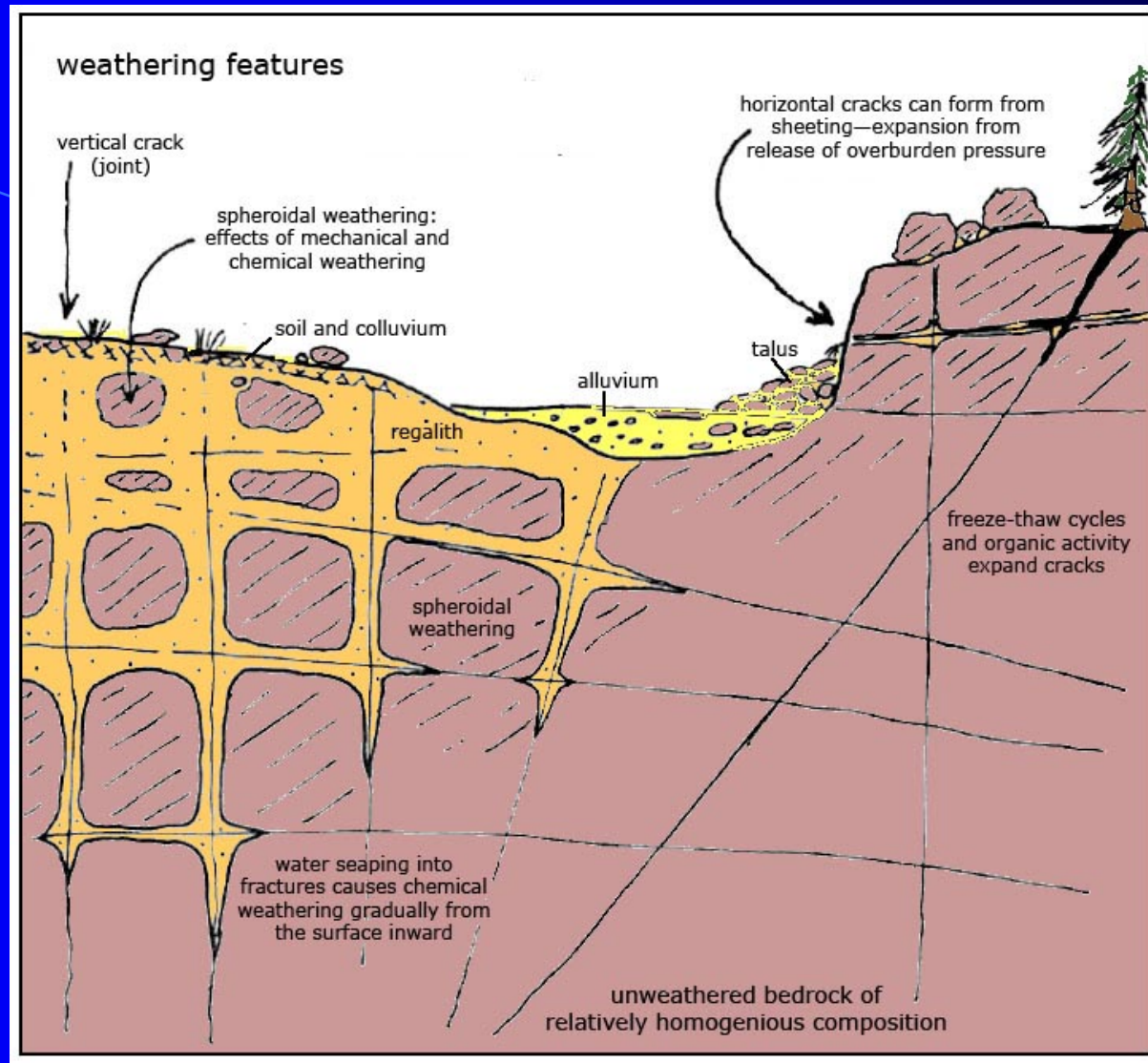
Rounding of the Corners



erosion brings sphere forms to the surface



Depth of weathering is a function of time and access (fractures)



Factors Controlling Rates of Weathering

Table 7.1 Major Factors Controlling Rates of Weathering

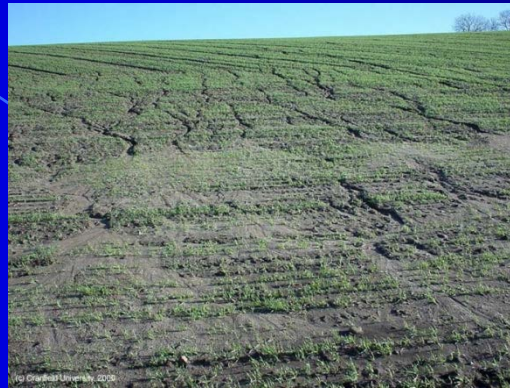
	Weathering Rate		
	Slow	→	Fast
PROPERTIES OF PARENT ROCK			
Mineral solubility in water	Low (e.g., quartz)	Moderate (e.g., pyroxene, feldspar)	High (e.g., calcite)
Rock structure	Massive	Some zones of weakness	Very fractured or thinly bedded
CLIMATE			
Rainfall	Low	Moderate	High
Temperature	Cold	Temperate	Hot
PRESENCE OR ABSENCE OF SOIL AND VEGETATION			
Thickness of soil layer	None—bare rock	Thin to moderate	Thick
Organic content	Low	Moderate	High
LENGTH OF EXPOSURE			
Short	Moderate	Long	

Table 9.3 Erosional Agents

Gravity (mass wasting)
Water (fluvial erosion)
Wind (aeolian erosion)
Glacial ice
Waves

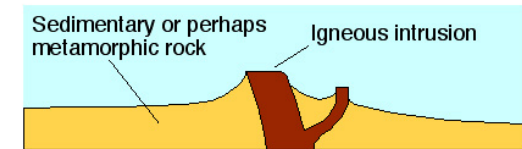
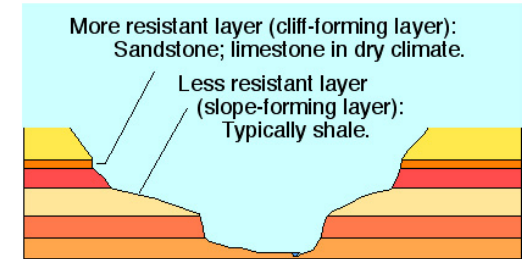
© 2006 Pearson Education, Inc.

Erosion



Differential Erosion:

Different rock types erode to give different slopes.



LBR 3/2002



Table 9.4 Variables Affecting Soil Erosion

Rainfall

- Intensity
- Duration

Soil Characteristics

- Porosity
- Permeability
- Moisture content
- Grain size and shape

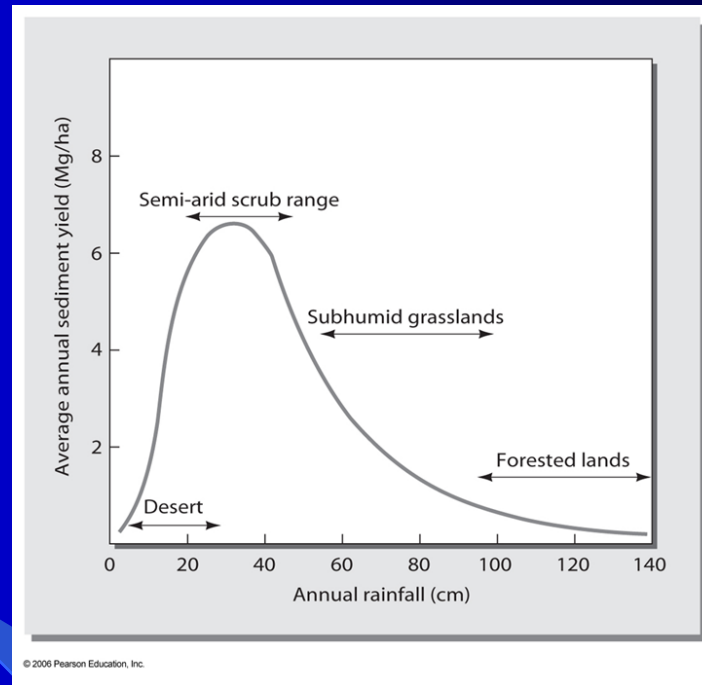
Topography

- Orientation of slope
- Slope angle
- Length of slope

Vegetation

- Type and distribution on slope

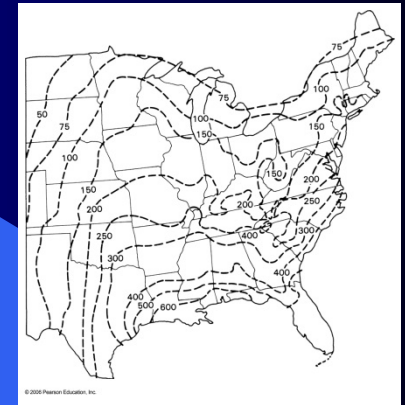
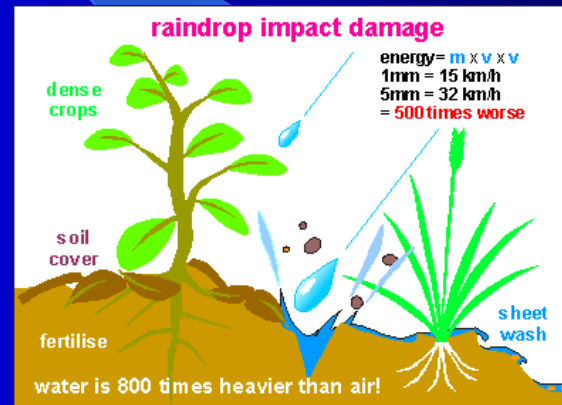
© 2006 Pearson Education, Inc.



© 2006 Pearson Education, Inc.

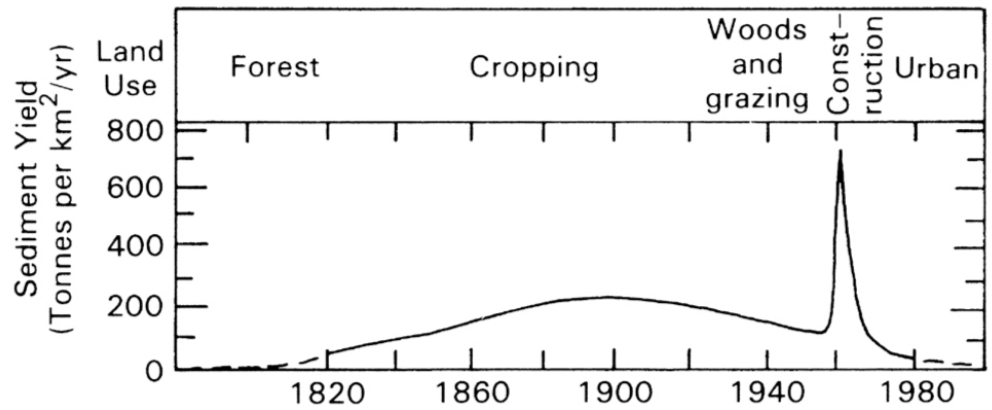
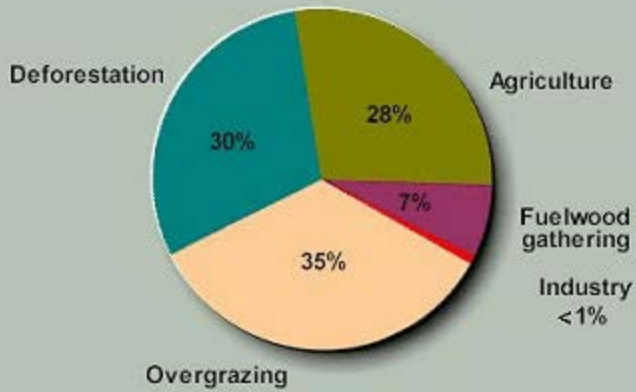
A = RKLSCP

- A = average annual soil loss (tons/acre)
- R = rainfall factor (see map)
- K = soil-erodibility factor
- LS = slope length – steepness factor
- C = cropping factor
- P = conservation factor



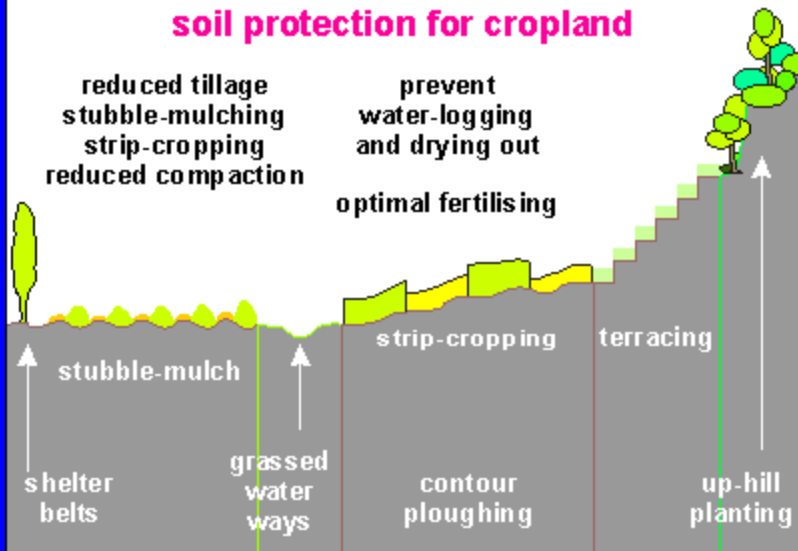
© 2006 Pearson Education, Inc.

Human Activities Causing Soil Degradation



© 2006 Pearson Education, Inc.

soil protection for cropland

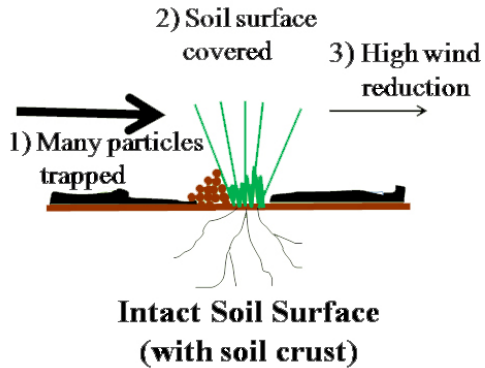


Erosion control



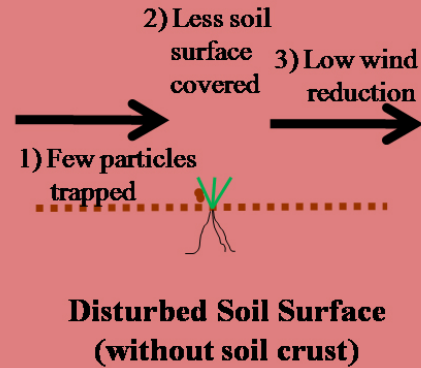
Low risk of dust storm

High Vegetation Cover



High risk of dust storm

Low Vegetation Cover



Open Wind Speed 20 mph 40 to 60% Density



Downwind Zone of Protection

h distance from windbreak	5h	10h	15h	20h	30h
miles per hour	6	10	12	15	19
% of open wind speed	30%	50%	60%	75%	95%

