

### Earth's external processes

- ❖ **Weathering** – the disintegration and decomposition of material at or near the surface
- ❖ Mass wasting – the transfer of rock material downslope under the influence of gravity
- ❖ Erosion – the incorporation and transportation of material by a mobile agent, usually water, wind, or ice

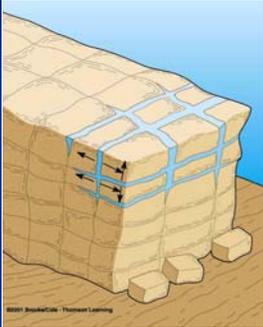
### How are Earth Materials Altered?

- Differential weathering and erosion
- Structural and chemical differences in rock can produce spectacular formations
- Mechanical weathering
- Chemical weathering



### How are Earth Materials Altered?

- **Mechanical Weathering**
  - Physical forces break rocks into smaller pieces that retain the chemical composition of the parent material
    - Frost action
    - Pressure release
    - Thermal expansion/contraction
    - Salt crystal growth
    - Organic activity



### Physical Weathering




## How are Earth Materials Altered?

- Pressure release
  - Exfoliation domes result from the expansion of plutons that formed under great pressure, but have been exposed by uplift and erosion



## Exfoliation in Granite

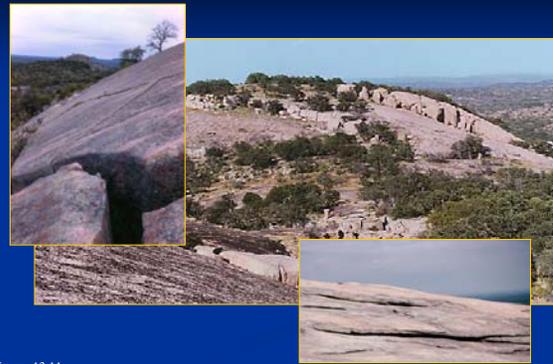
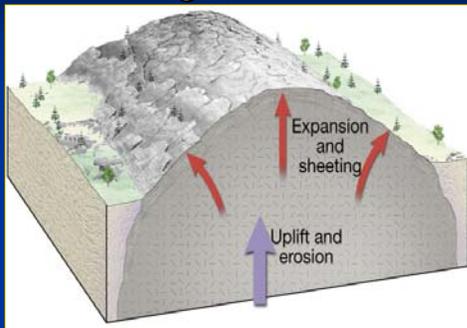


Figure 13.11

## Unloading and exfoliation of igneous rocks



## Weathering

### Chemical weathering

- Alters the internal structures of minerals by removing or adding elements
- Most important agent is water
  - Oxygen dissolved in water oxidizes materials
  - Carbon dioxide (CO<sub>2</sub>) dissolved in water forms carbonic acid and alters the material

## How are Earth Materials Altered?

- Chemical Weathering
  - Decomposition of parent material to produce new minerals and ions. Agents include atmospheric gases, water, and acids.
  - Other processes:
    - Solution
    - Oxidation
    - Hydrolysis

## Chemical Weathering

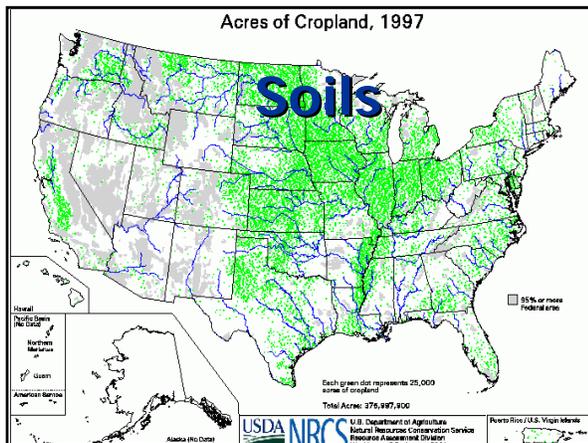
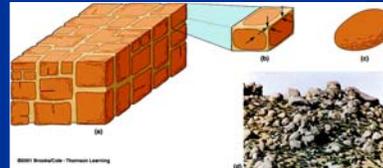




Physical weathering on Mt. Whitney in background  
Chemical weathering on Alabama Hills in foreground

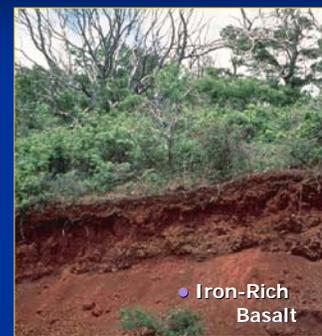
## Rates of weathering

- ❖ Advanced mechanical weathering aids chemical weathering by increasing the surface area
- Factors controlling the rate of chemical weathering
  - Stability of minerals is opposite their order of crystallization
  - Mechanical weathering increases the surface area of parent rock, enabling chemical processes to act more effectively
  - Presence of fractures, particle size, climate, parent material



## Overview

- Soil Formation
- Chemical and Physical Properties of Soils
- Soils and Human Activities



## What is Soil and How Does it Form?

- Soil is a mixture of weathered rock material, water, air, and organic matter
  - Sand, silt, and clay - weathered rock fragments
  - Humus - carbon rich decayed organic material
  - Residual soils - develop on parent rock
  - Transported soils - eroded and transported to another location where soil develops

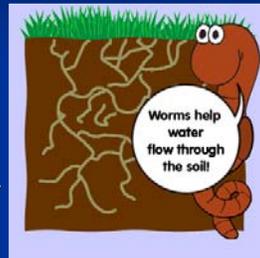
## Soil

- ❖ Controls of soil formation
  - Parent material – weathered bedrock
    - Residual soil – parent material is the bedrock
    - Transported soil – parent material has been carried from elsewhere and deposited
  - Time
    - Important in all geologic processes
    - Amount of time to evolve varies for different soils
      - Approximately 80 – 400 years for soil-forming processes to create 1 cm of topsoil.

## Soil

### ❖ Controls of soil formation

- Climate
- Plants and animals
  - Organisms influence the soil's physical and chemical properties
  - Furnish organic matter to soil



## Soil

### ❖ Controls of soil formation

- Slope
  - Angle
    - Steep slopes often have poorly developed soils
    - Optimum is a flat-to-undulating upland surface
  - Orientation (direction the slope is facing) influences
    - Soil temperature
    - Moisture

## Soil

### ❖ Soil types

- Hundreds of soil types worldwide
- Three very generic types
  - Pedalfer
    - Accumulation of iron oxides and Al-rich clays in the B-horizon
    - Best developed under forest vegetation

## Soil

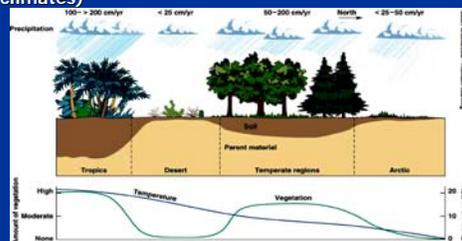
### ❖ Soil types

- Three very generic types
  - Pedocal
    - Accumulate calcium carbonate
    - Associated with drier grasslands
  - Laterite
    - Hot, wet, tropical climates
    - Intense chemical weathering

## What is Soil and How Does it Form?

### ■ Factors Controlling Soil Formation

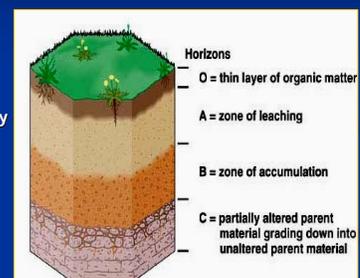
- Climate, relief, slope angle
- Three major soil types are recognized: pedalfer (humid climates), pedocals (arid climates), laterites (tropical climates)



## What is Soil and How Does it Form?

### ■ The Soil Profile

- O horizon
  - organic matter
- A horizon
  - top soil, intense biological activity
- B horizon
  - subsoil, zone of accumulation
- C horizon
  - little organic matter, partially altered parent rock



## Soil

### ❖ Soil Profile

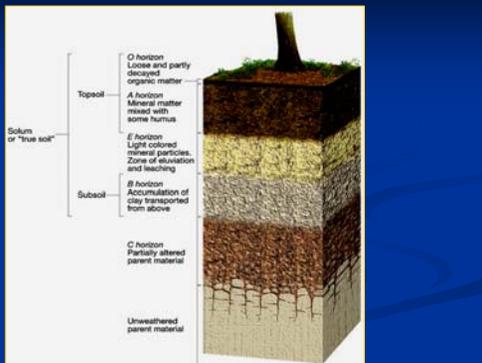
- Soil forming processes operate from the surface downward
- Horizons – zones or layers of soil
- Horizons in temperate regions
  - O – organic matter
  - A – organic and mineral matter
  - E – little organic matter

## Soil

### ❖ Soil Profile

- Horizons in temperate regions
  - B – zone of accumulation
  - C – partially altered parent material
- O and A together called topsoil
- O, A, E, and B together called solum, or "true soil"

## An idealized soil profile



## A soil profile showing different horizons



## Chemical and Physical Properties of Soils

- Color, Texture, and Structure of Soils
- Soil Classification

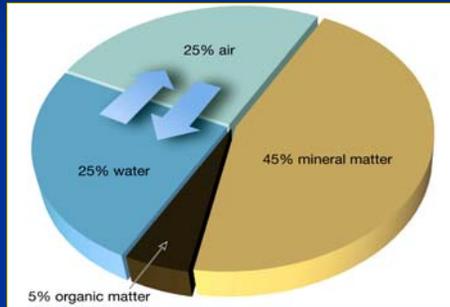
### SOIL ORDER:

A group of soils in the broadest category of the the USDA "Soil Taxonomy." The Soil Taxonomy is a basic system of soil classification for making and interpreting soil surveys. There are 12 orders, differentiated by the presence or absence of diagnostic horizons: Alfisols, Andisols, Aridisols, Entisols, Gelisols, Histosols, Inceptisols, Mollisols, Oxisols, Spodosols, Ultisols, and Vertisols. Orders are divided into Suborders and the Suborders are farther divided into Great Groups.

## Soil

- ❖ An interface in the Earth system
- ❖ Soil is a combination of mineral matter, water, and air – that portion of the regolith (rock and mineral fragments) that supports the growth of plants

## Typical components in a soil that yields good plant growth



## Soil

- ❖ Soil texture and structure
  - Texture refers to the proportions of different particle sizes
    - Sand (large size)
    - Silt
    - Clay (small size)
  - Loam (a mixture of all three sizes) is best suited for plant life

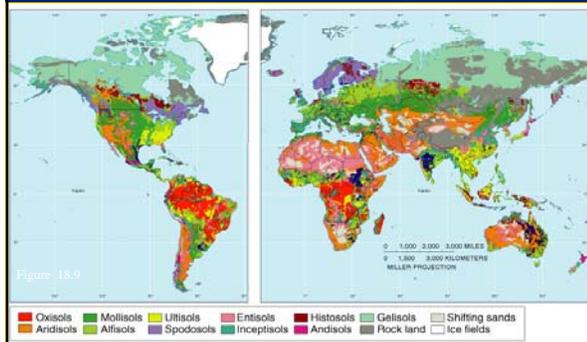
## Soil Texture Triangle



## Soil Classification

- Soil Taxonomy
- Diagnostic Soil Horizons
- The 12 Soil Orders of the Soil Taxonomy

## Soil Taxonomy



## Soil

TABLE 5.2 Summary of Soil Types

Climate	Temperate humid (>63 cm rainfall)	Temperate dry (<63 cm rainfall)	Tropical (heavy rainfall)	Extreme arctic or desert
Vegetation	Forest	Grass and brush	Grass and trees	Almost none, so no humus develops
Typical Area	Eastern U.S.	Western U.S.		
Soil Type	Pedalfers	Pedocals	Laterites	
Topsoil	Sandy, light-colored; acid	Commonly enriched in calcite; whitish color	Enriched in iron (and aluminum) brick-red color	No real soil forms, because there is no organic material. Chemical weathering is very slow.
Subsoil	Enriched in aluminum, iron and clay; brown color	Enriched in calcite; whitish color	All other elements removed by leaching	
Remarks	Extreme development in conifer forests, because abundant humus makes groundwater very acidic. Produces light gray soil because of removal of iron.	Caliche is name applied to the accumulation of calcite.	Apparently bacteria destroy humus, so no acid is available to remove iron.	

## Soil

### ❖ Soil texture and structure

- Structure
  - Soil particles clump together to give a soil its structure
  - Four basic soil structures
    - Platy
    - Prismatic
    - Blocky
    - Spheroidal

## Types of Soil Structure



Figure 18.5

## Properties of Soils



Munsell Color Book

## Soil

### ❖ Soil erosion

- Recycling of Earth materials
- Natural rates of erosion depend on
  - Soil characteristics
  - Climate
  - Slope
  - Type of vegetation

## Soil

### ❖ Soil erosion

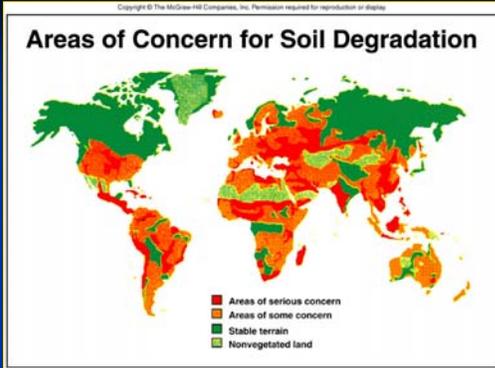
- Soil erosion and sedimentation can cause
  - Reservoirs to fill with sediment
  - Contamination by pesticides and fertilizers

## What is Soil and How Does it Form?

- Soil degradation is a decrease in soil productivity or loss of soil.



## Concern for Soil Degradation Worldwide



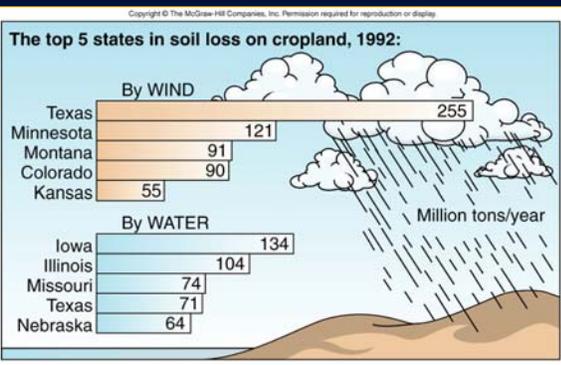
Source: Data from Global Resource Information Database of U.N. Environment Programme.

## Location of Soil Erosion by Wind or Water



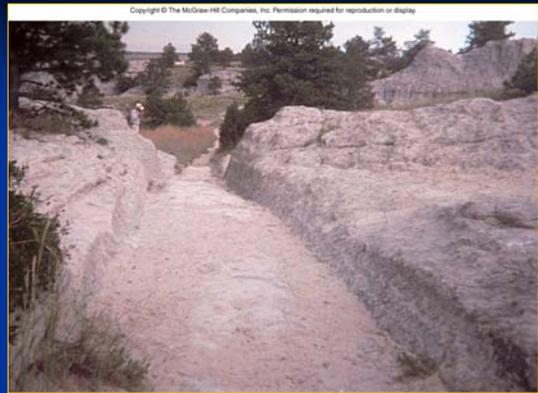
Source: Data from Global Resource Information Database of U.N. Environment Programme.

## Soil Loss Per State on Cropland

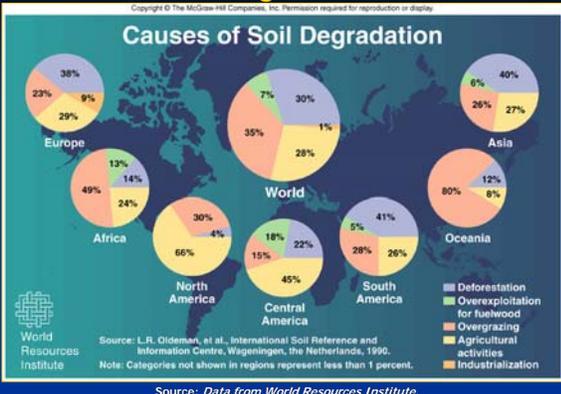


Source: National Resources Inventory April 1995, USDA Natural Resources Conservation Service.

## Oregon Trail Ruts Carved by Wagons



## Causes of Soil Degradation Worldwide



## EROSION CONTROL

**RURAL**  
 Contour plowing  
 Terracing  
 Wind Breaks  
 Riparian buffers  
 Silt ponds

**URBAN**  
 Silt fences  
 Storm drain filters  
 Detention ponds  
 Retention ponds

