

## Essentials of Geology, 11e

### Weathering and Soils

#### Chapter 5

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### Earth's External Processes

- **Weathering** – the physical breakdown (*disintegration*) and chemical alteration (*decomposition*) of rock at or near Earth's surface
- **Mass wasting** – the transfer of rock and soil downslope under the influence of gravity

### Earth's External Processes

- **Erosion** – the physical removal of material by mobile agents such as water, wind, ice, or gravity.



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Figure 5.1

### Weathering

- Two types of weathering
- **Mechanical weathering (1)** – breaking of rocks into smaller pieces
  - Four types of mechanical weathering
    - **Frost wedging** – alternate freezing and thawing of water in fractures and cracks promotes the disintegration of rocks

### Frost Wedging

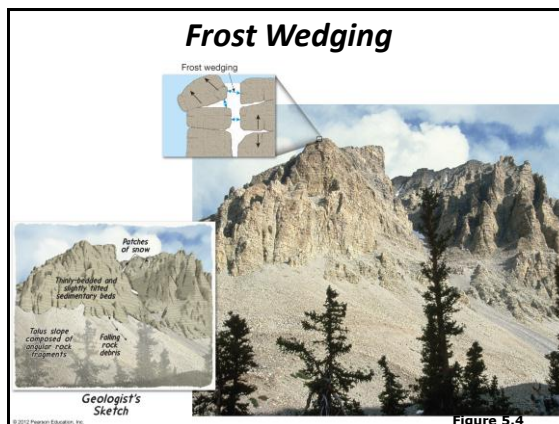


Figure 5.4

## Weathering

### – Mechanical Weathering, continued

- **Sheeting** – exfoliation of igneous and metamorphic rocks at the Earth's surface due to a reduction in confining pressure
- **Salt crystal growth**–expansion due to crystal growth (coastal and roads)
- **Biological activity** – disintegration resulting from plants and animals

## Exfoliation of Igneous Rocks

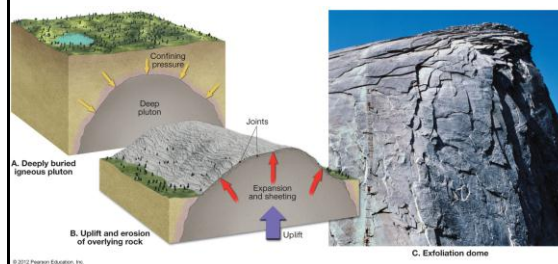


Figure 5.5

## Biologic Weathering



Figure 5.7

## Weathering

### • Chemical Weathering (2)

- Breaks down rock components and the internal structures of minerals
  - Most important agent involved in chemical weathering is **water** (responsible for transport of ions and molecules involved in chemical processes)

## Weathering

### • Major processes of chemical weathering

#### – Dissolution

- Aided by small amounts of acid in the water
- Soluble ions are retained in the underground water supply

#### – Oxidation

- Any chemical reaction in which a compound or radical loses electrons
- Important in decomposing ferromagnesian minerals



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Figure 5.12

## Weathering

- Major processes of chemical weathering
  - **Hydrolysis**
    - The reaction of any substance with water
    - Hydrogen ion attacks and replaces other positive ions

TABLE 5.1

### Products of Weathering

Mineral	Residual Products	Material in Solution
Quartz	Quartz grains	Silica
Feldspars	Clay minerals	Silica, K <sup>+</sup> , Na <sup>+</sup> , Ca <sup>2+</sup>
Amphibole (hornblende)	Clay minerals	Silica, Ca <sup>2+</sup> , Mg <sup>2+</sup>
	Limonite	
	Hematite	
Olivine	Limonite	Silica, Mg <sup>2+</sup>
	Hematite	

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Table 5.1

## Weathering

- Alterations caused by chemical weathering:
  - **Decomposition** of unstable minerals
  - **Generation** or retention of materials that are stable (new minerals form)
  - **Physical changes** such as the rounding of corners or edges

## Weathering

- Rates of weathering:
  - Advanced mechanical weathering aids chemical weathering by increasing the surface area.

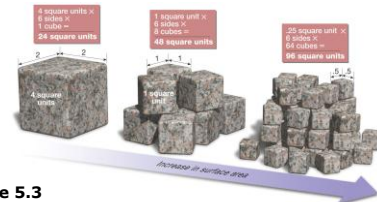


Figure 5.3

## Weathering

- Others factors affecting weathering
  - **Rock characteristics**
    - Rocks containing calcite (marble and limestone) readily dissolve in weakly acidic solutions.
    - Silicate minerals weather in the same order as their order of crystallization.
      - Think “**Bowen’s Reaction Series**”
      - The first mineral to form is often the first to weather on the surface.
      - Last mineral to form is often the last to weather on the surface.

## Weathering

- Others factors affecting weathering
  - **Climate**
    - Temperature and moisture are most crucial factors
    - Chemical weathering is most effective in areas of warm, moist climates

Figure 5.10 A & B



## Weathering

- **Differential weathering**
  - Masses of rock do not weather uniformly due to regional and local factors
  - Results in many unusual and spectacular rock formations and landforms



Figure 5.11

## Differential Weathering



Figure 5.13

## Soil

- **Soil** is a combination of mineral and organic matter, water, and air
  - That portion of the **regolith** (rock and mineral fragments produced by weathering) that supports the growth of plants
  - Up to 45% mineral matter

## Typical Components in a Soil that Yield Good Plant Growth

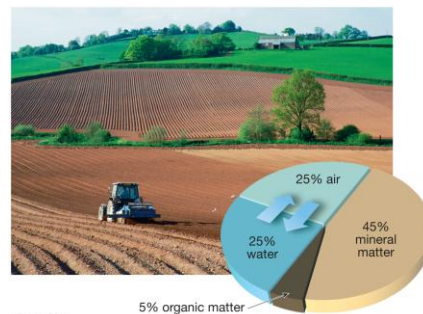


Figure 5.14

## Soil

- **Factors controlling soil formation**
  - **Parent material**
    - **Residual** soil – parent material is the underlying bedrock
    - **Transported** soil – forms in place on parent material that has been carried from elsewhere and deposited

## Soil

- **Factors controlling soil formation**
  - **Time**
    - Important in all geologic processes
    - Amount of time for soil formation varies for different soils depending on geologic and climatic conditions
  - **Climate**
    - Most influential control of soil formation
    - Key factors are temperature and precipitation

## Soil

- Factors controlling soil formation
  - **Plants and animals**
    - Organisms influence the soil's physical and chemical properties
    - Also furnish organic matter to the soil
  - **Slope (topography)**
    - Steep slopes often have poorly developed soils
    - Optimum terrain is a flat-to-undulating upland surface

## Soil Development

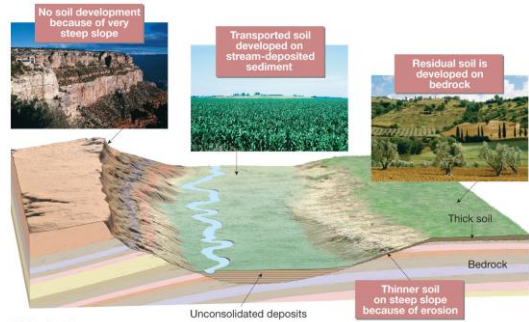


Figure 5.15

## Soil

- The **soil profile**
  - Soil forming processes operate from the surface downward
  - Vertical differences are called **horizons** – zones or layers of soil



Figure 5.17A

## Soil

- The soil profile
  - **O horizon** – organic matter
  - **A horizon** – organic and mineral matter
    - High biological activity
    - Topsoil (O+A)
  - **E horizon** – little organic matter
    - Zone of **eluviation and leaching**
    - Zone of breakdown and removal

## Soil

- The soil profile
  - **B horizon** – zone of accumulation
  - **C horizon** – partially altered parent material
- The O, A, E, and B horizons together are called the **solum**, or “true soil”

## An Idealized Soil Profile

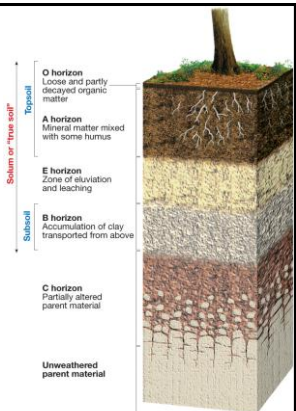
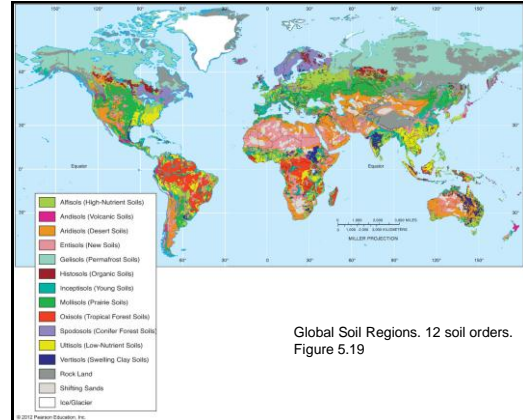


Figure 5.18

## Soil

- Soil types
  - Groups consist of items that have certain important characteristics in common
- Soils are classified using a system known as the **Soil Taxonomy**
  - Based on physical and chemical properties of the soil
  - Includes six hierarchical categories of classification, ranging from **order** (broadest) to **series** (most specific)
  - Useful for agricultural and related land-use purposes



## Soil

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

## Soil

- Soil erosion
  - In many regions the rate of soil erosion is significantly greater than the rate of soil formation
  - Sedimentation and chemical pollution
    - Related to excessive soil erosion
    - Occasionally soil particles are contaminated with pesticides



## Weathering and Ore Deposits

- **Secondary enrichment – concentrating metals into economically valuable concentrations**
  - By downward percolating water removing undesirable materials
  - By carrying desirable elements to lower zones and concentrating them

## Weathering and Ore Deposits

- **Bauxite**
  - Principal ore of aluminum
  - Forms in rainy tropical climates from chemical weathering and the removal of undesirable elements by leaching



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**Figure 5.24**

***End of Chapter 5***