Weathering and Soils
Earth 12th Edition
Chapter 6

Chapter 6 – Weathering & Soil

Weathering

- Weathering involves the physical breakdown and chemical alteration of rock at or near Earth's surface
  - Two types:
    - Mechanical weathering—physical forces breaking rocks into smaller pieces
    - Chemical weathering—chemical transformation of rock into new compounds
  - Both work simultaneously and reinforce each other

Interactions:

Mechanical Weathering

- Mechanical weathering, by breaking rock into smaller and smaller pieces, increases surface area for chemical weathering attack

Mechanical Weathering

- Types of Mechanical Weathering
  - Frost wedging
  - Salt crystal growth
  - Sheeting/Unloading
  - Biological activity
    -
    -
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Mechanical Weathering

- Frost wedging
  - Two different methods
    - Water works its way into cracks in rocks and the freezing enlarges the cracks in the rocks
    - Lenses of ice in soil grow larger as they attract liquid water from surrounding areas

Ice Breaks Rock

Mechanical Weathering

- Salt Crystal Growth
  - Sea spray or salty groundwater penetrates crevices and pore spaces in rocks
  - As the water evaporates, salt crystals form and enlarge the crevices
- Sheeting/*Unloading*
  - Large masses of igneous rock are exposed by erosion and concentric slabs break loose due to release of confining pressure
  - An exfoliation dome is formed after continued weathering causes slabs to separate and spall off

Unloading Leads to Sheeting

20 **Mechanical Weathering**
- Biological Activity
  - Plant roots grow into fractures in a rock, causing the cracks to expand (root wedging)
  - Burrowing animals break down rocks by moving fresh material to the surface, enhancing physical and chemical weathering
  - Human impacts (rock blasting) are very noticeable -- can produce effects much like unloading

21 **Mechanical Weathering**

22

23 **Chemical Weathering**
- The Most Important Agent Is Water
  - Responsible for transport of ions and molecules involved in chemical processes
- Processes of *Chemical Weathering*
  - Dissolution
  - Oxidation
  - Hydrolysis

24 **Chemical Weathering**
- Dissolution
  - Certain minerals dissolve in water
    - Halite is one of the most water-soluble minerals
  - A small amount of acid in water increases the corrosive force of water, causing dissolution
    - Carbonic acid is created when carbon dioxide dissolves in raindrops
    - Calcite is easily attacked by weakly acidic solutions
    - This process is responsible for the formation of limestone caverns

25 **Chemical Weathering (Dissolution)**

26 **Chemical Weathering**

27 ***Dissolution Cavity, Grand Canyon***

28 **Chemical Weathering**
- Oxidation
  - Essentially the rusting of iron-rich minerals
  - Oxygen combines with iron to form iron oxide
  - Process is slow in dry environments
  - Water increases the speed of the reaction
  - Important in decomposing ferromagnesian minerals like olivine, pyroxene, hornblende, and biotite
  - Oxidation can only occur after iron has been freed from the silicate structure by *hydrolysis*

29 **Chemical Weathering**

30 **Chemical Weathering**

31 **Chemical Weathering**
- Hydrolysis
  - The reaction of any substance with water
  - A hydrogen ion attacks and replaces another ion
  - Silicates primarily decompose by hydrolysis
    - Clay minerals are the most abundant product of weathering
    - Clay minerals are very stable under surface conditions
  - Acid greatly accelerates hydrolysis

32 **Chemical Weathering**
- Spheroidal Weathering
  - Weathering attacks edges from two sides and corners from three sides
  - Sharp edges gradually wear down and become rounded
  - Granite, for example:
    - Crystalline rock with joints

- Water penetrates joints
- H^+ replaces K^+ in the feldspars, disrupts crystalline structure

33 **Chemical Weathering**

34

35 ***Spheroidal weathering in Joshua Tree N.P.***

36 ***Spheroidal weathering in eastern S.D. County (note 18-wheeler for scale!)***

37 ***Weathering Cavities in Granite, Mortero Wash***

38 **Rates of Weathering**

- The rate of weathering is influenced by:
  - Rock Characteristics
    - Dependent of mineralogy
    - Silicate minerals weather in the same order as crystallization (Bowen's reaction series)
    - Carbonates and halides weather more quickly than silicates
  - Climate
    - Temperature and precipitation are crucial
      - Frequency of freeze-thaw
      - Moisture available for dissolution
      - Conditions favoring vegetation growth

39 **Chemical Weathering**

40 **Chemical Weathering**

41 **Rates of Weathering**

- Variations in local climate and the composition of the rock formation will produce uneven weathering of the rock called differential weathering

42 **Example of Differential Weathering**

43

44 **Weathering of silicate minerals**

(compare to Bowen's Reaction Series)

45 ***Products of weathering***

46 **Soil**

- Soil is "the bridge between life and the inanimate world"
  - The bridge between the various Earth systems
  - Earth's land surface is covered by a layer of rock and mineral fragments produced by weathering, called regolith
  - Soil is a combination of mineral and organic matter, water, and air and is the portion of the regolith that supports the growth of plants

47 **Soil**

- Soil Texture and Structure
  - Most soils are far from uniform
  - Soil texture refers to the proportions of different particle sizes
    - This property strongly influences the soil's ability to transmit and retain water and air
  - Four basic soil structures are recognized
    - Platy, prismatic, blocky, and spheroidal
    - Influences how easily the soil can be cultivated, how susceptible it is to erosion, porosity and permeability

48 **Soil**

49 **Controls of Soil Formation**

- Parent material, climate, plants and animals, time, and topography interact to control soil formation

50 **Controls of Soil Formation**

- Parent material
  - The source of weathered material that forms soil

- Residual soils—soils form from the underlying bedrock
- Transported soils—soils that form in place from unconsolidated sediment

- Climate
  - The most influential control of soil formation
  - Key factors are temperature and precipitation
    - Determines degree and rate of mechanical and chemical weathering

51 **Controls of Soil Formation**

- Plants and Animals
  - Influence the soil chemistry
  - Remains are converted into humus which is an important part of the organic component of soils
- Time
  - Weathering over a short period of time forms thin soils that closely resemble the parent material
  - Soils that have weathered for a long period of time are generally thick and do not resemble the parent material

52 **Plants Influence Soil**

53 **Controls of Soil Formation**

- Topography
  - Can vary greatly over short distances—leads to development of local soils
  - Steep slopes have poorly developed soils
    - Moisture content of these areas is often insufficient for plant growth due to rapid runoff
  - Flat and undulating surfaces are optimal for soil formation
    - Good drainage and minimal erosion
  - *Slope orientation* is also important in soil formation
    - Southern-facing slopes in the Northern Hemisphere receive the most sunlight are optimal for soil formation

54 **The Soil Profile**

- Soil-forming processes operate from the surface downward
  - Soil is divided into horizontal layers called horizons
  - A vertical section through all the soil horizons is called a soil profile
    - A mature soil has well-developed horizons
    - An immature soil may lack soil horizons

55 **The Soil Profile**

56 **The Soil Profile**

- *O soil horizon*—organic matter
  - The lower portion is composed of humus
  - This horizon includes bacteria, fungi, algae, and insects
- *A soil horizon*—organic and mineral matter
  - High biological activity
- O and A horizons make up the topsoil

57 **The Soil Profile**

- *E horizon*—little organic matter
  - Light-colored layer
  - Eluviation (washing out fine soil components to lower soil layers) is common in this layer
  - Soluble inorganic components are washed to lower layers in a process called leaching
- *B horizon* (subsoil)—zone of accumulation
  - Material washed down from the E horizon accumulates in this layer

58 **The Soil Profile**

- Collectively, the O, A, E, and B horizons make up the solum, or “true soil”
- *C horizon*—partially altered parent material
  - Parent material is difficult to identify in the O, A, E, and B horizons

59 **The Soil Profile**

60 **Classifying Soils**

- Variations in soil formation over time and distances has led to a great variety of recognized soil types
- Groups have been established using common characteristics
- In the United States, a system was devised and called the Soil Taxonomy
  - Includes 6 hierarchical categories
  - System recognizes 12 soil orders and more than 19,000 soil series

61 **Basic Soil Orders**

62 **Global Soil Regions**

63 **The Impact of Human Activity on Soils**

- The agricultural productivity of soils can be improved through fertilization and irrigation
- Soils can be damaged or destroyed by careless activities
  - Soils are crucial for providing food, fiber, and other basic materials
  - Soils are one of the most abused resources

64 **The Impact of Human Activity on Soils**

- Clearing the Tropical Rain Forest: A Case Study of Human Impact on Soil
  - Tropical forests are cleared for logging and agricultural use
  - Soils in tropical forests are poor in nutrients and unsuitable for agriculture
    - Most of the nutrients in tropical rain forests are found in the trees
  - Clearing tropical rain forests also promotes soil erosion

65 **The Impact of Human Activity on Soils**

66 **Tropical Deforestation**

67 **The Impact of Human Activity on Soils**

- Soil Erosion: Losing a Vital Resource
  - Soil erosion is a natural process in the *rock cycle*
    - However, soil formation is slow
  - Erosion rates are dependent on climate, slope, and type of vegetation
    - Human activities such as deforestation and farming practices can enhance soil erosion
    - Water flowing on deforested ground starts as *sheet erosion* on the surface, this becomes tiny channels called *rills*, that grow into *gullies*—which cannot be remediated by normal cultivation

68 **The Impact of Human Activity on Soils**

69 **Controlling Soil Erosion**

- On every continent unnecessary soil loss is occurring
  - When steep slopes are farmed, constructing terraces can help slow runoff and decrease soil loss
  - Strips of grass or cover crops parallel to slope also slow runoff and trap sediment
  - Creating grassed drainage ways prevents the formation of gullies and traps soil

70 **Examples of Soil Conservation**

71 **Examples of Soil Conservation**

72 **Examples of Soil Conservation**

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