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2 ***Chapter 6 – Weathering & Soil***

3 **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

4 **Mechanical Weathering**

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

5 **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

6 **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

7 **Mechanical Weathering**

8 **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) is very noticeable- can produce effects much like unloading

9 **Mechanical Weathering**

10 **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

11 **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

12 **Chemical Weathering**

13 **Chemical Weathering**

14 **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 ferromagnesium minerals like olivine, pyroxene, hornblende, and biotite
  - Oxidation can only occur after iron has been freed from the silicate structure by *hydrolysis*
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    -

15 **Chemical Weathering**

16 **Chemical Weathering**

17 **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
    -
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18 **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

19 **Chemical Weathering**

20 **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

21 **Chemical Weathering**

22 **Chemical Weathering**

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

24 **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

25 **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

26 **Soil**

27 **Controls of Soil Formation**
- Parent material, climate, plants and animals, time, and topography interact to control soil formation

28 **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

29 **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

30 **Soil**

31 **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

32 **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

33 **The Soil Profile**

34 **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

35 **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

36 **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

37 **The Soil Profile**

38 **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

39 **Global Soil Regions**

40 **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

41 **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

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

43 **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

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

45 **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

46 **Examples of Soil Conservation**

47 **Examples of Soil Conservation**

48 **Examples of Soil Conservation**

49

End of Chapter 6