Weathering and Soil

Earth 9th edition, Chapter 6

Weathering: summary in haiku form

Rocks brought to surface
decompose to sediment
and that's weathering.

Key Concepts

- "Weathering" and Earth's external and internal processes.
- Processes of mechanical weathering.
- Processes of chemical weathering.
- Controls on rates of weathering processes.
- Soil and soil-forming processes.
- The "soil profile" and soil taxonomy.
- Soil erosion and controls on rates.

Earth's External Processes

- Weathering
  - Disintegration
    - Physical breakdown of rocks at or near earth's surface
  - Decomposition
    - Chemical alteration of rocks at or near earth's surface
- Mass wasting
    - Transfer of rock and soil downslope under the influence of gravity

Earth's External Processes

- Erosion
  - Physical removal of material by mobile agents such as water, wind, ice or gravity

Weathering

- Two types of weathering
  - Mechanical weathering
    - Breaking of rocks into smaller pieces
  - Chemical weathering
    - Breaking down of internal structures of minerals

Mechanical Weathering

- Four types of mechanical weathering
  - Frost wedging
    - Alternate freezing and thawing of water in fractures promotes the disintegration
  - Unloading
    - Exfoliation of igneous and metamorphic rocks at earth's surface due to a reduction in confining pressure

Mechanical Weathering

- Four types of mechanical weathering (continued)
  - Thermal expansion
    - Alternate expansion and contraction due to heating and cooling of rocks
  - Biological activity
    - Disintegration resulting from plants and animals

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20 ***Chemical Weathering***

- Breaking down of internal structures of minerals by chemical means
- Water
  - Responsible for transport of ions and molecules involved in chemical processes

21 ***Chemical Weathering***

- Major processes of chemical weathering
  - Dissolution
    - Aided by small amounts of acid in the water
    - Soluble ions are carried away in the underground water supply
  - Oxidation
    - Any chemical reaction in which a compound or radical loses electrons
    - Important in decomposing ferromagnesian minerals

22 ***Dissolution Cavity, Grand Canyon***

23

24 ***Oxidation of Iron***

Hematite
(= Fe_2O_3,
or "rust")

25 ***Chemical Weathering***

- Major processes of chemical weathering (continued)
  - Hydrolysis
    - The reaction of any substance with water
    - The hydrogen ion attacks and replaces other positive ions

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

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29 ***Products of weathering***

30 ***Weathering***

- Alteration caused by chemical weathering
  - Decomposition of unstable minerals
  - Generation or retention of materials that are stable
  - Physical changes such as the rounding of corners or edges

31 ***Weathering***

- Rates of weathering
  - Advanced mechanical weathering aids chemical weathering by increasing the surface area
- Other factors affecting weathering
  - Rock characteristics
    - Rocks containing calcite (limestone and marble) readily dissolve in weakly acidic solutions

32 **Increase in surface area**

33 ***Weathering***

- Other factors affecting weathering
  - Rock characteristics (continued)
    - Silicate minerals weather in the same order as their order of crystallization
      - (i.e., Bowen's reaction series)
  - Climate
    - Temperature and moisture are the most critical factors

- Chemical weathering is most effective in areas of moist, warm climates

34 **Weathering of common silicate minerals**

35 ***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

36 ***Differential weathering controlled by jointing patterns***

37 ***Joint-controlled weathering in igneous rocks***

38 ***Joint-controlled weathering in igneous rocks***

39 ***Soil***

- Combination of mineral and organic matter, water, and air
  - Portion of the regolith that supports growth of plants
    - Regolith = rock and mineral fragments produced by weathering

40 ***Typical components in a soil that yields good plant growth***

41 ***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 from elsewhere and deposited

42 ***Soil***

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

43 ***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
    - Steep slopes often have poorly-developed soils
    - Optimum terrain is flat to undulating upland surface

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45 ***Variations in soil development due to topography***

46 ***Soil***

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

47 ***Soil***

- The soil profile
  - O horizon
    - Organic matter
  - A horizon
    - Organic and mineral matter
      - High biological activity

- Together, the O and A horizons make up the topsoil
- E horizon
  - Little organic matter
    - Zone of eluviation and leaching

48 ***Soil***

- The soil profile
  - B horizon
    - Zone of accumulation
  - C horizon
    - Partially altered parent material
  - The O, A, E and B horizons are called the solum
    - "true soil"

49 ***Idealized soil profile***

50 ***A soil profile showing different horizons***

51 ***Soil***

- Soil types
  - The characteristics of each soil type primarily depend on the prevailing climatic conditions
- Three very generic soil types
  - Pedalfer
    - Accumulations of iron oxides and Al-rich clays in the B horizon
    - Best developed under forest vegetation

52 ***Soil***

- Three very generic soil types
  - Pedocal
    - High accumulations of calcium carbonate
    - Associated with dry grasslands and brush vegetation
  - Laterite
    - Hot and wet tropical climates
    - Intense chemical weathering

53 ***Soil***

54 ***Soil***

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

55 ***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

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