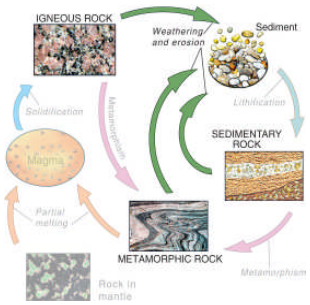
Chapter Outlines

The Rock Cycle



NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>

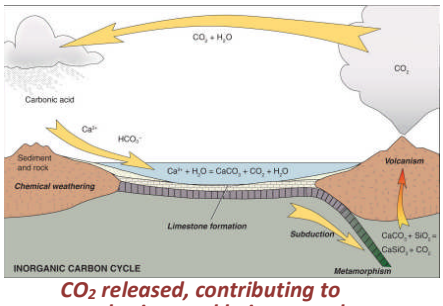
Weathering

The process of **weathering** alters rocks at the earth's surface and breaks them down over time into fine-grained particles of sediment and soil. Weathering is the result of the interactions of air, water, and temperature on exposed rock surfaces and prepares the rock for erosion. **Erosion** is the movement of the particles by ice, wind, or water. The particles are then **transported** by that agent until they are **deposited** to form sedimentary deposits, which can be later eroded again or transformed into sedimentary rocks. The weathering of the sediment grains continues during erosion and transportation. Weathering is generally a long, slow process that is continuously active at Earth's surface

<u>Weathering and Earth Systems -</u> The Sun is indirectly responsible for weathering through the creation of wind, rain, glaciers, various climates, and vegetation

- **Atmosphere**
  - oxygen and carbon dioxide are critical to chemical weathering
  - water cycled through atmosphere is also critical to chemical & mechanical weathering processes
  - chemical weathering removes carbon dioxide from the atmosphere, helping keep global temperatures from soaring
- **Hydrosphere**
  - water is necessary for chemical weathering
  - oxygen dissolved in water **oxidizes iron** in rocks
  - carbon dioxide dissolved in water creates **carbonic acid** ***(H_2CO_3)***
  - running water loosens and abrades particles
  - glacial ice removes and abrades particles
  - freeze/thaw cycling mechanically weathers rock

Roots breaking rock



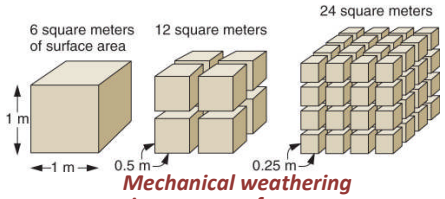
CO_2 released, contributing to weathering, and being stored

- **Biosphere**
  - plant root growth widens cracks
  - animal movement and human activity mechanically weather
  - decaying organic matter in soils produces acidic soil moisture

<u>Types of Weathering</u> – Mechanical and Chemical weathering

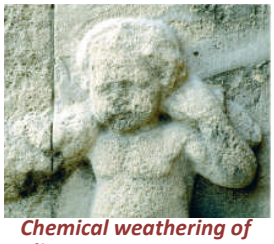
- **Mechanical Weathering -** a reduction in grain size *(disintegration)* without an accompanying change in chemical/mineral composition. May occur by:
  - Frost action *(freezing and thawing)*
  - Pressure release *(Half Dome is example)*
  - Organic activity
  - Borrowing animals
  - Thermal expansion and contraction
  - Salt crystal growth
  - Abrasion

Freeze/ thaw cycles

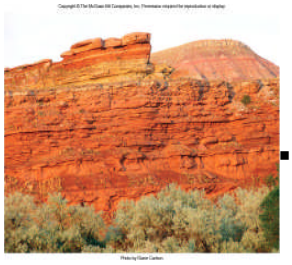


Mechanical weathering increases surface area

- **Chemical Weathering** - chemical changes in rocks/minerals as Earth materials react at the surface with Earth's surface environment, principally carbon dioxide, oxygen, and water vapor. Involves decomposition of minerals, and often formation of new minerals. The most important reactions occur by oxidation or hydrolysis *(both CO_2 and Oxygen are highly reactive components of the atmosphere):*
  - Solution weathering *(calcite/limestone)*
    - Acidity is key
    - CO_2 in the atmosphere makes all rain acidic. $CaCO_3$ *(calcite/limestone)* dissolves to ions. Generalized reaction: $H_2CO_3 + CaCO_3 \rightarrow$ the ions Ca^{++} and HCO_3^-
  - Oxidation *(rust)*



Chemical weathering of limestone monument

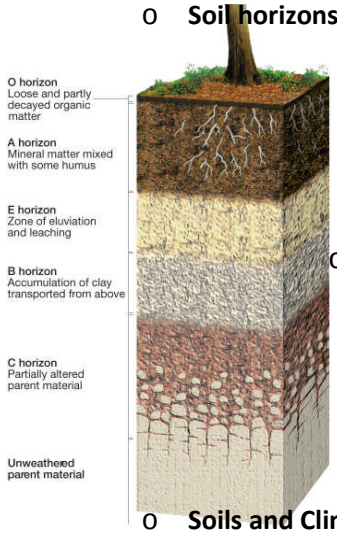


Oxidation of iron-rich sedimentary rock

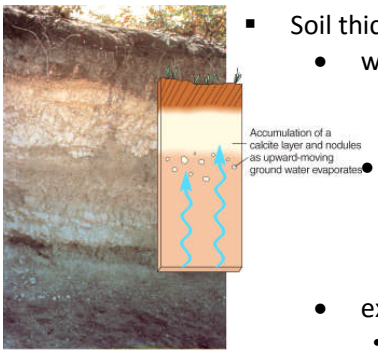
- Oxygen from the atmosphere combines with iron to form iron oxide. Generalized reaction: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
- Hydrolysis *(silicate minerals)*
  - Reaction between water *(acidic from CO_2 in the atmosphere or ground)* and minerals
  - Feldspars *(and other silicate minerals)* dissolve to clay and other products. Sample reaction: $2KAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 + 2K^+ + 2HCO_3^-$
- Mechanical and chemical weathering usually occur together, with their effects being interrelated.
- Example: Granite weathers to clay, quartz sand, and dissolved ions.
- Weathering rates are affected by:
  - Surface area; more surface = faster weathering
  - Climate; warmer and wetter = faster weathering
  - Parent materials; Bowen's Reaction Series gives the general trend in reverse
  - Presence of plants and animals; more plants = faster weathering
  - Topography; steeper gradient = faster weathering due to quick removal of weathered materials

Soil

- **Soil** – when rock weathers in place and is not transported away, a soil profile will form. Common soil constituents include: ***clay minerals, quartz, water, organic matter.*** It normally consists of *(these classifications sometimes vary!):*
- **Soil horizons**



  - ***O horizon*** - uppermost layer; organic material
  - ***A horizon*** –surface, dark-colored, rich in organic matter and high in biological activity
  - ***E horizon*** - zone of leaching; fine-grained components removed by percolating water
  - ***B horizon*** - zone of accumulation; clays, iron oxides, and aluminum leached down from above; formation of ***hard pan*** in wet climates
  - ***C horizon*** - partially weathered bedrock
- **Soil Development Over Time**
  - **Residual soil** - weathering of underlying rock
  - **Transported soil** – *(either soil or loose material that will become soil)* brought in from elsewhere
    - wind-transported soil is called ***loess***
  - **Soil composition** – determined by parent rock composition and climate
    - evolves with time and chemical weathering
  - **Soil thickness** – increases with time, thicker in wetter climates and areas of low slopes
- **Soils and Climate**



Creation of 'hardpan'

  - Soil thickness and composition are greatly affected by climate
    - wet climates:
      - more chemical weathering and thicker soils
      - tend to have significant clay-rich layers, which may be solid enough to form a ***hardpan***
    - arid climates:
      - less chemical weathering and thinner soils
      - subsurface evaporation leads to build-up of salts
      - calcite-rich accumulation zones may form, cementing soil together into a ***hardpan***
    - extremely wet climates
      - highly leached and unproductive soils (***laterites***)
      - most nutrients come from thick O/A horizons
- **Soil Erosion**

The hills are eroded, then the sediment is transported by the stream

  - Soil particles are small and are therefore easily eroded by water and wind
    - water erosion is the most significant type
    - wind erosion is generally less significant
    - a problem in arid and semiarid regions
    - depleted agricultural soils require increased use of fertilizers
    - rates of erosion influenced by: ***soil characteristics, climate, slope, vegetation***
  - Consequences of erosion: loss of topsoil, damage to buildings, etc.