Chapter 6
Weathering, Soil, and Sedimentary Rocks

How are Earth Materials Altered?

- Differential weathering and erosion

  - Structural and chemical differences in rock can produce spectacular formations
  - Spheroidal weathering –
- **Mechanical and Chemical weathering**
  - decomposition and/or disintegration of rock and minerals at the surface
  - why weathering occurs

- **Mechanical Weathering**
  - Physical forces break rocks into smaller pieces that retain the chemical composition of the parent material

- Types
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- Frost action or wedging

- Pressure Release
  - Cracking of rock due to a decrease in pressure
    - this occurs when a pluton is uplifted towards the surface
  - Exfoliation: when large sheets of rock splits of a larger rock mass like layers of an onion.
    - Granite behaves this way. Why?
      - Granite contains f-spar which chemically combines with water to form clay. It is bigger in size, therefore, rock expands and peels off in sheets
Slabs of granitic rock bounded by sheet joints in the Sierra Nevada of California. The slabs are inclined downward toward the roadway visible at the lower left.
Notice in this image that the sheet-joint bounded slabs have started moving down-slope toward the road.

Exfoliation Domes North Dome and Basket Dome are two of many exfoliation domes in Yosemite National Park, California. In the distance you can see several other exfoliation domes.
- Thermal expansion and contraction
  - occurs during periods of heating and cooling, causing the rock to crack

- Salt cracking
  - water evaporates leaving crystals that exert pressure on the rock

- Organic activity
  - roots expand and crack the rock (works just like frost wedging)
- Abrasion
  - grinding of rock surfaces by friction and impact.
  - agents of abrasion
  - 
  - 

[Diagram of pH scale showing different substances and their pH values.]

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Before we discuss Chemical weathering, you need to have a basic understanding of acids and bases

**Acids**

- **Properties**
  - - Litmus:
  - - Contain ions (H⁺)

- **Strong acids**
  - - Hydrochloric acid: HCl
  - - Sulfuric acid: H₂SO₄ used in manufacturing
  - - Nitric acid: HNO₃ fertilizers and explosives

- **Weaker acids**
  - - Carbonic acid:
  - - Boric acid:
  - - Acetic acid
  - - Citric acid

**Bases**

- **Properties**
  - - Litmus:
  - - emulsify or
  - - Contain ions (OH⁻)

- **Strong bases**
  - - Sodium Hydroxide NaOH
  - - Potassium Hydroxide KOH
  - - Calcium Hydroxide Ca(OH)₂ plaster
  - - Magnesium Hydroxide Mg(OH)₂
- Weak bases
  - Ammonium Hydroxide \( \text{NH}_4\text{OH} \)
  - Aluminum Hydroxide \( \text{Al(OH)}_3 \)

**pH** – a measure of hydronium ion concentration (\( \text{H}_3\text{O}^+ \))

\[
\text{H}_3\text{O}^+ + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ 
\]

- *Acids = proton donor*
- scale of 0-14

\[
\begin{align*}
0 &= \\
14 &= \\
7 &= \\
\end{align*}
\]

example:

\[
\begin{align*}
\text{pH } 4 &= .0001 \text{ g/L of } \text{H}_3\text{O}^+ \\
&= .0000000001 \text{ g/L of } \text{OH}^- \\
\text{pH } 7 &= .0000001 \text{ g/L of } \text{H}_3\text{O}^+ \\
&= .0000001 \text{ g/L of } \text{OH}^- \\
\text{pH of } 1 &= 10^{-1} \text{ g/L of } \text{H}_3\text{O}^+ \\
\text{pH of } 13 &= 10^{-13} \text{ g/L of } \text{H}_3\text{O}^+ \\
\end{align*}
\]
- **Chemical Weathering**
  - Decomposition of parent material to produce new minerals and ions. Agents include atmospheric gases, water, and acids.

- **Other processes:**
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- **Air:** O₂, water, CO₂

- **O₂:** Likes to react with many other elements. We refer to this process as ex. Rusting

  \[ 4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3 \text{ (hematite)} \]

- **CO₂:** Dissolves in water to form a weak acid called

  \[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^- \]

  *These reactions are said to be reversible*

  - **Precipitate:** when a solid “falls out” of solution
- **Water:** due to molecular structure and asymmetrical shape that makes the water bipolar.

- When some solids come into contact with water they **dissolve**.
- Acid Rain
  - is released from burning fossil fuels
  - \( \text{SO}_2 \) is formed
  - \( \text{SO}_2 \) combines and reacts with \( \text{H}_2\text{O} \) and \( \text{O}_2 \)
  to form \( \text{H}_2\text{SO}_4 \) ( ) a strong acid.
  - \( \text{HNO}_3 \) ( ) is very similar in how it reacts in the environment
  
- hydrolysis: hydrogen ions ( ) replace positive ions in minerals. Changes the composition of minerals.
  
- cations\(^+\)
  1) \( \text{K}^{+1}, \text{Ca}^{+2}, \text{Mg}^{+2}, \text{Na}^{+1} \): 
  2) \( \text{Fe}^{+2}, \text{Al}^{+2} \) :
  3) \( \text{Si}^{+2} \) :
  
- Weathering of feldspars
  - makes up
  - Granite =
  - f-spar weathers much more easily than quartz
  
- Example: Potassium f-spar ( )
  \( \text{KAlSi}_3\text{O}_8 \)
  - the K gets kicked out by the \( \text{H}^{+} \) and forms clay
  
- F-spar weathers to clay
  - If weathers in dry environment all cations present:
  - If weather in moist environment K and some Silicon are removed:
- Factors controlling the rate of chemical weathering
  - Stability of minerals is opposite their order of crystallization
  - Mechanical weathering increases the surface area of parent rock, enabling chemical processes to act more effectively
  - Presence of

![Surface area images]

Soil

- Soil is a mixture of
  - weathered rock fragments
  - carbon rich decayed organic material
  - develop on parent rock
  - eroded and transported to another location where soil develops

- Regolith: loose, unconsolidated, weathered rock on top of the bedrock. Stuff on top of the native rock.

- Soil: Upper part of regolith that supports plant life.
- What is in Soil?

- Plants need
  - Nutrients: nitrogen, phosphorous, potassium. Calcium, magnesium, sulfur
  - Air:
  - Water: Purpose?

- Loam: mixture of sand, clay, silt and organic material

- Litter: organic matter on the surface that has not decayed yet

- Humus: decomposed material
  - Function:
Soil Profiles

- Distinct layers of the soil

**O Horizon:**
- O =
- composed of
- few minerals

**A Horizon:**
- second layer (surface soil)
- humus and minerals
- (+) Ca, Mg, K, Na, and Si get out of this horizon

= 30% by weight + organic

Per Kg

- 2 trillion
- 400 million
- 50 million
- 30 million
- thousands of other things:

**B Horizon:**
- third layer (subsoil)
- zone between
- cations(+) Ca, Mg, K, Na, and Si here
- roots
- low in organic matter
C Horizon:
- Partially weathered rock
- Almost no organic matter

Bedrock:
- Under C Horizon
Factors that control soil type and formation

- **Parent rock:**
  - helps determine if soil is made of
  - ex. Granite:
    - Basalt:
  - also helps determine nutrient abundance

- **Time:**
  - young soils = low clay
  - older soil = sand and clay (from feldspar)
  - as time goes on, soil will mix with

- **Climate:**
  - the amount will help determine the degree of leaching
  - three major soil types characteristic of different climates

- **Pedocals:**
  - soil type that forms when water down through to and is then is pulled back out by , capillary action, and plant absorption.
- The dissolved ions are left behind to form caliche (containing calcium carbonate)
- happens in dry areas
- Salinization: soil becomes salty

- Pedalfers:
  - soil type that forms when the ions are leached from A and B.
  - less soluble ions Al and Fe accumulate in B
  - moderate rainfall

- Laterites:
  - soil type that forms when intense rainfall leaves only Fe and Al
  - bauxite: comes from granite that weathered and had more soluble ions leached out
- Decay and growth Rates
  - Dry areas =
  - Cold areas =
  - Tropics =
  - Temperature =

- Slope and aspect
  - soil accumulations in the floors
  - compass direction
  - south side gets more sun, therefore, more vegetation