

## Minerals and Sedimentary Rocks

### Sedimentary Processes

- Weathering
  - Physical Weathering
    - Physical Process... no new minerals
  - **Chemical Weathering**
    - Reaction of rocks with gases or liquids
    - New minerals formed at the expense of less stable minerals
- Transport
  - Physical Process... no new minerals
- Deposition
  - Settling
    - Physical process... no new minerals
  - **Precipitation**
    - Growth of new minerals from oversaturated solutions
- **Diagenesis**
  - Mineral transformations and growth in the subsurface
    - Cementation is another form of precipitation

### Chemical Weathering

- Solution
  - $\text{H}_2\text{CO}_3 + \text{CaCO}_3 \rightarrow \text{Ca}^{2+}_{(\text{aq})} + 2\text{HCO}_3^{-}_{(\text{aq})}$ 
    - Dissolution of calcite in carbonic acid
  - $\text{NaCl} \rightarrow \text{Na}^{+}_{(\text{aq})} + \text{Cl}^{-}_{(\text{aq})}$ 
    - Dissolution of halite in water
- *Would you expect to find halite in outcrop?*
- *Would you expect to find halite in thin-section?*

### Chemical Weathering

- Hydrolysis
  - In hydrolysis a molecule is split into two parts by reacting with water. One product includes an  $\text{OH}^-$  from the water molecule, whereas  $\text{H}^+$  is added to another
  - $\text{Mg}_2\text{SiO}_4 + 4\text{H}^+ + 4\text{OH}^- \rightleftharpoons 2\text{Mg}^{2+}_{(\text{aq})} + 4\text{OH}^- + 4\text{H}_4\text{SiO}_4^{\text{aq}}$ 
    - Hydrolysis of forsterite results in all products in solution
  - $2\text{KAlSi}_3\text{O}_8 + 2\text{H}_2\text{CO}_3 + 9\text{H}_2\text{O} \rightleftharpoons \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 4\text{H}_4\text{SiO}_4^{\text{aq}} + 2\text{K}^+ + 2\text{HCO}_3^-$ 
    - Hydrolysis of orthoclase produces kaolinite
  - $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 5\text{H}_2\text{O} \rightleftharpoons 2\text{Al}(\text{OH})_3 + 2\text{H}_4\text{SiO}_4^{\text{aq}}$ 
    - Hydrolysis of kaolinite produces gibbsite
- *What would happen to albite or anorthite due to hydrolysis?*
- *What would form from feldspar-rich rocks in warm and wet environments?*

## Bauxite



- Bauxite is the main ore of aluminum
- Forms due to tropical weathering
- Composed primarily of gibbsite
- *What is the red material?*

## Chemical Weathering

### • Oxidation

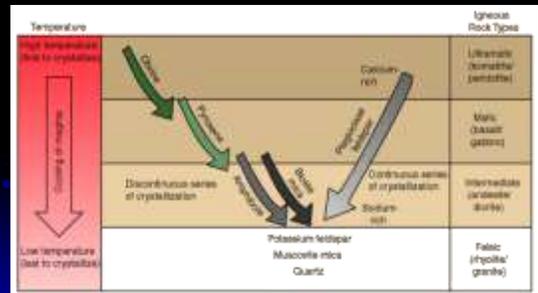
- $4\text{FeS}_2 + 15\text{O}_2 + 22\text{H}_2\text{O} \rightarrow 4\text{FeO(OH)} + 8\text{SO}_4^{2-} + 16\text{H}^+$ 
  - Oxidation of pyrite to form limonite
- Iron oxides and hydroxyoxides occur within bauxite, and give it a rusty-red color.
  - *Where did the Fe come from? Pyrite?*

## Chemical Weathering

### • Combined Hydrolysis and Oxidation

- $4\text{FeSiO}_3 + \text{O}_2 + 8\text{H}_2\text{O} \rightarrow 2\text{Fe}_2\text{O}_3 + 4\text{H}_4\text{SiO}_4$ 
  - Oxidation and hydrolysis of pyroxene to form hematite
- *What would be the products of the chemical weathering of:*
  - Hornblende  $\text{Ca}_2(\text{Mg,Fe,Al})_6(\text{Al,Si})_8\text{O}_{22}(\text{OH})_2$
  - Biotite  $\text{K}(\text{Fe,Mg})_3\text{AlSi}_3\text{O}_{10}(\text{F,OH})_2$
  - Diopside  $\text{CaMgSi}_2\text{O}_6$

## Bowen's Reaction Series



## Chemical Weathering



Start with feldspars and Fe-bearing silicates...



End with clays, limonite, hematite, and a loss of Si, Ca, Na, and K into solution

## Deposition by Precipitation (Chemical Sediments)

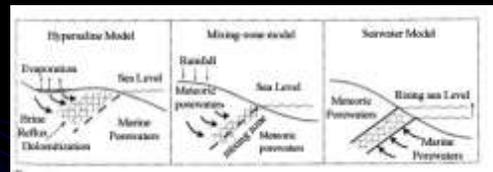
- Normal seawater has a salinity of 35g/kg
- Only 6 ions comprise 99% of the ions dissolved in seawater:
  - Cl<sup>-</sup> 55.04 wt%
  - Na<sup>+</sup> 30.61 wt%
  - SO<sub>4</sub><sup>2-</sup> 7.68 wt%
  - Mg<sup>2+</sup> 3.69 wt%
  - Ca<sup>2+</sup> 1.16 wt%
  - K<sup>+</sup> 1.10 wt%
- Minerals that form as marine precipitates will be composed of these ions.
- *What minerals form as marine precipitates?*
- *Where did K, Na, Ca, and Mg come from?*

## Deposition by Precipitation (Chemical Sediments)

Mineral	Composition	Solubility (mol/l)
Calcite	CaCO <sub>3</sub>	0.00014
Magnesite	MgCO <sub>3</sub>	0.001
Gypsum	CaSO <sub>4</sub> •2H <sub>2</sub> O	0.0154
Halite	NaCl	6.15
-----	CaCl <sub>2</sub> •6H <sub>2</sub> O	7.38

Why is CaCl<sub>2</sub>•6H<sub>2</sub>O not a naturally occurring evaporite mineral?

## Dolomitization



## Diagenesis: Cementation

- Precipitation of minerals from solutions in pore water
- Composition of ground water varies greatly depending on such variables as bedrock composition and rainfall
  - *Calcite and dolomite might develop in hard-water areas*
  - *Clays and quartz might develop in soft-water areas*
  - *Limonite and hematite may occur in rocks that are rich in iron*
  - *Pyrite may occur in rocks where the pore waters were anoxic*

## Dolomitization

