Weathering

When you talk about sedimentary rocks, you have to talk about weathering.

Weathering

- Clastic rocks - conglomerates, sandstones, mudrocks are composed of fragments and solid weathering products of pre-existing rocks.
- Even carbonate rocks and cements, whose constituents are precipitated from seawater by biological organisms, are made from ions that come from the weathering process.

Two aspects to Weathering

- Mechanical Weathering - physical breakup of rocks.
- Chemical Weathering - chemical breakdown of minerals in the presence of water.
- Mechanical Weathering is trivial compared to chemical weathering, due to the extraordinary dissolving power of $H_2O$.

Mechanical Weathering

- Abrasion by wind- or water-carried fragments.
- Frost-wedging is most important agent of mechanical weathering.
- Water freezes to ice *9% volume increase*.
- Most important where water is liquid in daytime and freezes every night.
- Most important mechanism for increasing surface area of rocks.

Chemical Weathering
• H₂O is polar; therefore, good at dissolving ions
• H₂O dissociates into H⁺ and OH⁻
• H⁺ reacts readily with minerals
• Weathering is probably aided by organic acids and microorganisms
• Different minerals weather at different rates

• Weathering of minerals depends on their chemical stability in the weathering environment: low T, low P, high H₂O, oxidizing
• What factors probably control the weathering rates of minerals?
• Consider olivine, biotite, quartz and plagioclase

Goldich’s Weathering Series – see handout

Note similarity to Bowen’s Reaction Series, Why?
Summarizes susceptibility of minerals to weathering

Weathering Reactions of Orthoclase

Step 1: 3 KAlSi₃O₈ + 2 H⁺ + 12 H₂O --> KAl₃Si₃O₁₀(OH)₂ + 6 H₄SiO₄ + 2 K⁺

orthoclase illite (~muscovite) soluble silica

Step 2: 2 KAl₃Si₃O₁₀(OH)₂ + 2 H⁺ + 3 H₂O --> 3 Al₂Si₂O₅(OH)₄ + 2 K⁺

illite kaolinite

All feldspars weather similarly

• React with H₂O and H⁺
• Release silica in solution and cations
• Produce clay minerals (sheet silicates)
• Albite + H₂O + H⁺ = Sodium montmorillonite + H₄SiO₄ + Na⁺
• Anorthite + H₂O + H⁺ = Calcium montmorillonite + H₄SiO₄ + Ca²⁺

Montmorillonite

• Montmorillonite formula: (Na,Ca)(Al,Mg)₂(Si₄O₁₀)(OH)₂·nH₂O
• Montmorillonites are EXPANDING clays (unlike illite and kaolinite)
• Al is essential in all clay minerals (i.e., Al in weathered silicates goes into clay minerals)
• Mg silicates also weather to form montmorillonite

Iron in minerals weather differently

• Fe in most ferromagnesian minerals is reduced (Fe\(^{2+}\)), because they’re formed in reducing conditions (low oxygen)
• Surface waters are very oxygen-rich, i.e., oxidizing
• Fe\(^{2+}\) released during weathering immediately oxidizes to Fe\(^{3+}\)
• Fe\(^{3+}\) precipitates rapidly as EXTREMELY INSOLUBLE Fe(OH)\(_3\) and other hydroxides

Weathering of pyroxene, for example

\[ \text{CaFeSi}_2\text{O}_6 \text{ (Fe part of augite) + H}_2\text{O} + \text{H}^+ = \text{Calcium montmorillonite + H}_4\text{SiO}_4 + \text{Ca}^{2+} + \text{Fe(OH)}_3 \]

The most common products of weathering are:

• Quartz
• Clay minerals-kaolinite, illite, montmorillonite
• Cations in solution
• Ferric hydroxides and oxides (insoluble) from the weathering of mafic minerals

Which will weather more rapidly, basalt or granite? Why?

Weathering of Basalt

• What will be the most common sand-sized fragments?
• What will be the most common mineral weathering products?
• Weathered ash deposits form bentonite - a mixture of clay minerals, mostly montmorillonite - expand when wet, very slippery!
Weathering of Granite

- Where does alteration first occur?
- Disaggregation of grains: forms "grus"
- Surface (esp. of feldspars) gets soft and punky, why?
- What are the mineral products of granite weathering?

Grus: disaggregated grains of quartz and feldspar from Granite