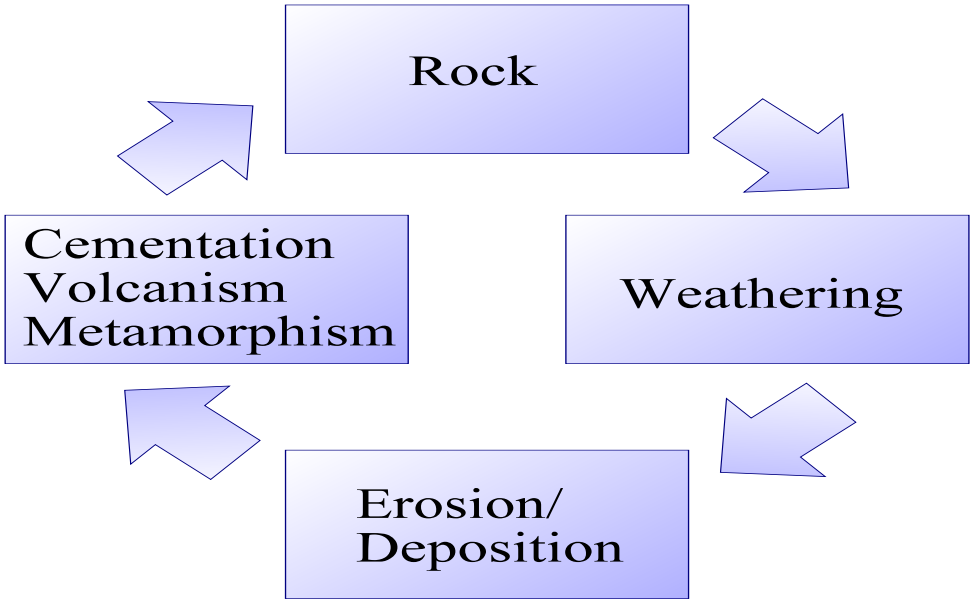
Weathering

Prior to soil formation, a media in which the soil can form must be available. As noted earlier, some media may be transported via ice, wind, water, or gravity. Ice and gravity often have large rocks, as does bedrock. These particles must weather in order to have a media (parent material) available for soil formation.

Weathering is a part of the rock cycle taught in elementary school: Rocks weather into smaller particles, erosion carries those particles away, eroded particles are deposited, and through sedimentary, metamorphic, or volcanic processes,, may become a rock again.



Physical - mechanical, disintegration - reduction in particle size only.

(Think of breaking a a cracker into smaller pieces, or of breaking a piece of chalk. The smaller pieces still have all the properties of the original cracker or chalk.)

affected by 1. temperature

2. frost action

3. erosion and deposition

4. plant and animal activities

Chemical - reduction of size and alteration of properties - six types (described later in detail)

(Now put the cracker in your mouth. Chewing continues physical weathering, but as saliva mixes with the cracker, it changes. It no longer has the properties of a cracker. Mixing a piece of chalk with vinegar or hydrochloric acid changes the properties so that it is no longer chalk.)

Factors affecting rate of weathering

Climate - Temperature, precipitation (intensity and amount), and wind. Temperature and precipitation have the greatest influence. Chemical and biological activity increase with temperature, so warmer climates have the potential for much greater weathering, if water is available. Wetter climates have more chemical and biological weathering than dry climates. So the most intensive weathering environment is one that is both hot and wet, e.g., tropical rainforests.

Physical characteristics of the rock and minerals -

1. Particle size - Coarse-grained minerals weather more rapidly than fine-grained ones
2. Hardness - Softer minerals weather more rapidly than hard ones
3. Cementation
    a. nature - All cementing agents are not created equal: Silica is a much harder cementing agent than gypsum or carbonates, so gypsum and carbonate cemented minerals weather more rapidly than silica cemented ones.
    b. degree: Minerals with little cementation weather more rapidly than those with more extensive cementation
4. Chemical characteristics - Chemical composition determines which forms of chemical weathering processes will dominate. Minerals that dissolve (like salts) weather more rapidly than those that do not.
5. Physical characteristics - These include hardness, specific gravity, surface area, etc. Crystalline structure influences many of these traits. Minerals with greater surface area weather more rapidly than those will little surface area. Minerals with greater surface area tend to have greater specific gravity, as well.

Types of Chemical Weathering

Hydrolysis - Greek (hydro, water; lysis, to cut) to cut or split a water molecule. Water weakly dissociates in solution, providing a hydride (cation) and a hydroxyl (anion). The ions react with minerals in the soil, forming anions and cations that react to form acids and bases.

$$H_2O \rightleftharpoons H^+ + OH^-,$$

$$KAlSi_3O_8 + H_2O \rightarrow HAlSi_3O_8 + KOH$$

(Orthoclase feldspar) → (Acid silicate clay, more soluble)

Hydration - Combination of water with a mineral. (When you are dehydrated, you need to add water to your system.)

$$2Fe_2O_3 + 3H_2O \rightarrow 2Fe_2O_3 \bullet 3H_2O$$

(Hematite) → (Limonite)

(Primarily red) (Primarily yellow)

(Thus, the hydration status of iron is a strong determinant of soil color.)

Dissolution - (sounds like dissolve) - Soluble minerals (like salts) dissolve in solution, meaning they separate into anions and cations.

$NaCl + H_2O \rightarrow Na^+ + Cl^- + H_2O$

Salt — Sodium and chloride ions

Acidification, carbonation - This is the reaction of a mineral with carbonic acid. How does carbonic acid get into soil? All organisms (including soil organisms) respire, and most use oxygen as the terminal electron acceptor during metabolism of carbohydrates to obtain energy, emitting carbon dioxide as the by-product. This carbon dioxide reacts with water (from precipitation or irrigation) in the soil to form carbonic acid, which in turn reacts with soil minerals like calcium or magnesium.

$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^-$

Carbonic acid $\rightleftarrows$ Bicarbonate

$Ca^{2+} + 2HCO_3^- \rightleftarrows Ca(HCO_3)_2$

calcium bicarbonate

$Ca(HCO_3)_2 \rightleftarrows CaCO_3 + H^+ + HCO_3^-$

calcium bicarbonate $\rightleftarrows$ calcium carbonate

Oxidation - loss of an electron, chemical combination of a mineral and oxygen

Reduction - gain of an electron (resulting in a reduction in charge since electrons have a negative charge - This is how I keep these terms straight.)

Oxidation and Reduction are companion processes - when one element is oxidized, another is reduced.

$$4FeO + O_2 \underset{\text{reduction}}{\overset{\text{oxidation}}{\rightleftharpoons}} 2Fe_2O_3$$

ferrous oxide — ferric oxide

more soluble, primarily gray — less soluble, primarily red

valence = 2^+ — valence = 3^+

Thus, oxidation and reduction affect both the solubility of minerals and the dominant soil colors.