Weathering: The Breakdown of Rocks

Mechanical Weathering: Breaks rocks into smaller particles
Chemical Weathering: Alters rock by chemical reactions

Mechanical Weathering
1) Ice Wedging
   *Results from 9% expansion when water turns to ice.
   *High stress (110kg/cm², about the wedge of a sledge)
   *It occurs when:
   >Adequate supply of moisture
   >Have preexisting fractures, cracks, and voids
   >Temperature rises above and below freezing
   *Was even used in some quarry operations to break up rock

2) Sheeting
   *Results from release of confining pressures
   *Has been observes directly in quarries and mines, even in roadways
   *Sheeting from heat results in a rock spalling
   *Spalling: surface of rock expands due to extreme heating but core of rock remains cool

3) Disintegration
   *Breakdown of rock into smaller pieces by critters, plants, etc.

Results of Mechanical Weathering
■Talus Cones (From ice wedging mostly)
■Boulder fields (From ice wedging mostly)
■Jointing: Cracks in the rock from ice wedging and sheeting

Chemical Weathering: Rocks are decomposed and the internal structure of the minerals is destroyed, and new minerals are created.

1) Hydrolysis: Chemical union of water and a mineral
   *Ex. Feldspar → clay mineral
   Water first form carbonic acid by combining with carbon dioxide in the reaction:
   \[ H_2O + CO_2 = H_2CO_3 \]
   Then the mineral is broken down:
   \[ 4NaAl_3Si_3O_8 + 4H_2CO_3 + 18H_2O → 4Na + 4HCO_3 + 8H_4SiO_4 + Al_4O_10(OH)_3 \]
   (Plagioclase) (carbonic acid) (water) (Dissolved components) (clay mineral)
   Sodium becomes displaced

2) Dissolution: Process where by rock material passes directly into solution, like salt in water
   *Most important minerals to do this: CARBONATES (Calcite;dolomite)
Dissolution (continue)
- Water is a universal solvent due to its polar nature
- Behaves like a magnet
- A good example is limestone which is made of calcite or dolomite
- In wet areas, it forms valleys
- In arid areas, it forms cliffs
- Some rock types can be completely dissolved and leached (flushed away by water)
- Best examples are natural salt (halite) and gypsum.
- As a result, guess where you find the best examples of this stuff?

Quartz Dissolution
- Although Quartz is stable in contact with water, it will also dissolve in common surface water according to the following reaction:
  \[ \text{SiO}_2 + 2\text{H}_2\text{O} \rightarrow \text{H}_4\text{SiO}_4 \]
  (Quartz) (water) (Silicic Acid)
- Each Year, rivers carry 3.9 million metric tons of dissolved minerals to the oceans.
- Not a surprise that seawater contains 3.5% dissolved salts, all of which came from the continents!

3) Oxidation: Combination of oxygen in the atmosphere or dissolved in water, with a mineral to form a new mineral
   *One or more of the components of the new mineral will have a higher oxidation state (or ionic charge)

Iron (Fe) has two common oxidation states:
   \[ \text{Fe}^{2+} \text{ and Fe}^{3+} \]
Oxygen prefers Fe\(^{3+}\)

Oxidation is especially important in the weathering of iron-rich minerals like olivine, pyroxenes, and amphiboles:

Olivine oxidation
  \[ 2\text{Fe}_2\text{SiO}_4 + 4\text{H}_2\text{O} + \text{O}_2 \rightarrow 2\text{Fe}_3\text{O}_3 + 2\text{H}_4\text{SiO}_4 \]
  (olivine) (water) (oxygen) (hematite) (dissolved silicic acid)

What changes the rates of these reactions?
   Temperature, plants, critters
Weathering Characteristics of Common Rocks

1) Granite
   ■ Composed of feldspar, quartz and mica
   ■ Forms at considerable depth, pressure and temperature, therefore out of equilibrium with the surface
   ■ Coarse grained
   ■ Mechanical Weathering: Exfoliation, a form of sheeting from pressure release
   ■ Chemical Weathering: Feldspar to clays, micas to chlorite

2) Basalt
   ■ Composed of feldspar, olivine and pyroxene
   ■ Forms at the surface, extrusively out of a volcano
   ■ Chemical weathering: feldspars to clays, olivine and pyroxene to iron oxides
   ■ Weathering product results in a brown to red soil

3) Sandstone
   ■ Composed mostly of quartz grains with rock fragments, feldspar and clay minerals
   ■ Forms at the surface from a river, beach, as a dune, etc
   ■ Chemical weathering: Largely on the cement of the rock which is usually calcite, iron oxides, or quartz.
   ■ Mechanical weathering: Granular disintegration, one grain at a time

4) Limestone
   ■ Composed of the mineral calcite although it may contain clays and other materials
   ■ Forms in water from mostly dead critter parts
   ■ Chemical weathering: dissolution (soluble in water)
   ■ Weathering products: Cliffs in arid regions, slopes in humid regions.
   ■ Caves, sinkholes, karst topography

5) Shale
   ■ Composed of clays, weathers fast
   ■ Forms in a gentle environment such as a lake, offshore marine
   ■ Mechanical weathering: Due to water content, ice wedging, disintegration
   ■ Chemical weathering: Due to clay mineral structure
   ■ Clays are phyllosilicates which form sheets of atoms, water molecules can break sheets apart easily.
The importance of fractures and joints in weathering

Almost all rocks are broken in a system of fractures that greatly influence the weathering of rock bodies in two ways:

- They effectively cut large blocks of rocks into smaller ones, thereby increasing the surface area where chemical reactions take place
- Joints and fractures act as channel ways through which water can penetrate to break down rock by ice wedging

Geometric Patterns of Rock Disintegration

- Joint Block Separation
- Bedding Plane Separation
- Jointing
- Shattering
- Spheroidal Weathering

*The process by which corners and edges of a rock body become rounded as a result of exposure to weathering on all sides, so that the rock acquires a spheroidal or ellipsoidal shape. (Exfoliation)

- Differential Weathering: Different rock bodies or different sections of the same rock that weather at different rates

The Major Products of Weathering

- Regolith, meaning blanket, composed of bedrock
  *Can range from a few centimeters to hundreds of meters, depending on climate, type of rock, and length of time that weathering processes have been operating.
  *The uppermost layer of regolith is the soil.
  *Soil is composed chiefly of small particles of rocks and minerals, plus varying amounts of decomposed organic matter.
  *Soil Profiles show a constant sequence of layers, or horizons, which are distinguished by composition, color and texture.

- Blanket of loose, layered rock debris>>Rock bodies modified into spheroidal shapes
  *Through exfoliation, a form of sheeting
Soil Formation
■ Climate is of major importance in the formation of soils
■ Other factors
  * Parent rock material
  * Topography

Soil Facts
■ Thickest soils in the tropics
■ Quartz generally forms thin infertile soils
■ Deserts often form thick eluviation horizons
■ Well-drained areas form rich, thick soils.

Climate and Weathering
■ Climate is the single most important factor influencing weathering
■ It determines not only the type and rate of weathering, but also the characteristics of regolith and weathered rock surfaces.
■ Intense chemical weathering occurs in hot, humid regions and develops thick regoliths
■ Chemical weathering is minimal in deserts and polar regions.

Rates of Weathering
■ The rate at which weathering processes decompose and breakdown a solid rock body depends on three main factors:
  1) Susceptibility of the constituent minerals to weathering
  2) Climate
  3) The amount of surface exposed to the atmosphere

Examples that help determine weathering rates
■ Pyramids in Egypt (Central Park, NY)
■ Krakatoa (Used a variety of types of rock)