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/cm^2, 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:

$$4NaAl_3Si_3O_8 + 4H_2CO_3 + 18H_2O \rightarrow 4Na + 4HCO_3 + 8H_4SiO_4 + Al_4O_{10}(OH)_3$$

(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:
$SiO_2 + 2H_2O \rightarrow H_4SiO_4$
(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:
Fe^{2+} 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
■$2Fe_2SiO_4 + 4H_2O + O_2 \rightarrow 2Fe_2O_3 + 2H_4SiO_4$
(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