G202 Weathering and Sedimentary Rocks

I. Basic Definitions

A. Denudation of the Earth's surface

1. Dynamic interaction between uplift of Earth's crust and erosion of materials

B. Weathering - disintegration and decomposition of rock at or near the surface of the earth, fragmenting rock into particles
1. Physical Weathering - physical breakdown
2. Chemical Weathering - chemical weathering and dissolution

C. Sediment - fragments of rocks and/or minerals that are produced from the weathering of pre-existing rock
1. Examples: clay, silt, sand, gravel, boulders

D. Erosion - incorporation and transportation of sediment by a mobile agent
1. Agents of Transportation
   a. wind (e.g. sand dunes, atmosperic dust)
   b. water (rivers, coastal areas)
   c. ice (glaciers)
   d. gravity

E. Mass wasting - transfer of rock material downslope under the influence of gravity

II. Weathering - surface processes operating on rock from the earth's crust

A. Driving mechanism of rock weathering
1. Igneous and metamorphic rocks
   a. Form at High temperature, High pressure
2. Rock exposure at Earth's surface
   a. uplift and denudation
3. Surface: low temperature / low pressure environment
   a. Water-rich environment
4. High temp / high pressure rocks are unstable in water-rich, low temp/low press. environment of Earth's surface
   a. Weathering drives system to new equilibrium state

B. Physical or Mechanical Weathering

1. defined: physical diminution or fragmentation of the rock
   a. sediment = fragmented rock particles
   b. sediment composition is controlled by the mineralogy of the parent rock that was subject to weathering

      (1) e.g. weathering of granite produces sediment rich in feldspar and quartz

2. Frost Wedging - process of alternate freezing and thawing of water/moisture

contained in cracks and fractures of rock.

a. liquid water to ice: ~9% volume expansion
b. "wedging" apart pieces of rock to form sediment

(1) e.g. TALUS SLOPES - found at base of cliffs or mountain fronts

3. Unloading or release of overburden pressure - particularly common in weathering of granite bodies, e.g. Yosemite National Park.
   a. rock expansion as it is exposed and "unroofed" at the Earth's surface via denudation

   b. Sheeting - rock breaking into concentric, onion-like slabs

4. Thermal Expansion - rock heating / differential expansion
   a. Hot desert regions (e.g. Death Valley)
   b. Forest Fire

5. Organic/Biologic Activity - activities of plants, animals, and humans can act as a weathering agent.
   a. root wedging
   b. burrowing organsims

C. Chemical Weathering

1. Defined - complex chemical processes at the surface of the earth that alter the internal atomic structure of minerals by removing and/or adding elements.

   a. Chemical agents of weathering:

      (1) Water - H_2O - universal solvent
         (a) dipolar molecule

      (2) Carbon dioxide - CO_2 - Carbon dioxide dissolved in water (H_20), produces carbonic acid (H_2CO_3),

         (a) hydrogen in the acid readily displaces any metal ions in minerals and results in producing clay minerals (hydrous aluminum silicates).

   b. Clay Minerals - the stable end product of chemically weathering silicate minerals ("igneous minerals")

      (1) "Clay" - two uses of the term
         (a) a grain size term (very fine mud particles)
         (b) a mineral family
            i) hydrous layered minerals
            ii) stable minerals at Earths' surface

2. Stable vs. Unstable Minerals

a. the higher the temperature of mineral formation, the less stable the mineral is chemically at the Earth's surface
b. vice - versa, lower-termp. minerals are more stable

(1) e.g. quartz is very stable at Earth's surface
(a) commonly forms sand at the beach

D. Rates of Weathering (How fast, over time, rocks weather)

1. Factors influencing rates

a. Particle size -
(1) small particles = faster reaction (greater surface area)
(2) large particles = slower reaction

b. Mineral Composition - different minerals have different resistance to weathering
(1) based on atomic structure, quality of chemical bonds, and temperatures as which mineral crystallize

c. Climatic factors influence weathering

(1) Freeze-thaw climate
(a) Canada - Yes / Brazil - No
(2) Chemical weathering climate
(a) hot, humid, abundant rainfall = yes!
(b) cold / arid = no!

III. Sedimentary Rocks

A. Sedimentary Rocks- rocks that are derived and formed at the earth's surface.

1. "sedimentary" - latin root means "settling" - e.g. sediment settling in water

2. A process of weathering in which the atmospheric processes at the earth's surface slowly disintegrate and decompose the igneous rocks. Sediment is generated (e.g. sand or gravel) via weathering and subsequently transported by running water, gravity, waves, glaciers, wind and sediment is deposited. After sediment is lithified or cemented into solid rock (analogous to concrete).

3. Sed. rocks account for only 5% of the earth's crust/lithosphere, however they cover 75% of the earth's surface exposures. The sedimentary environment is a surface environment (at surface pressures and temperatures)

4. Rock Interpretation = reconstruction of ancient sed. environments (e.g. river, shallow ocean, deep ocean, lagoon, lake, swamp).
(1) fossils

5. Sedimentary rocks are where we find many natural resources such as coal and

oil, also many ore minerals are found in sedimentary rock "hosts".

B. Basic Terminology

1. Weathering - disintegration and decomposition of rock at or near the surface of the earth, fragmenting rock into particles

2. Sediment - fragments of rocks and/or minerals that are produced from the weathering of pre-existing rock

3. Erosion - incorporation and transportation of sediment by a mobile agent, usually water, wind, or ice.

4. Lithification - refers to the process of converting loose sediment or mud into solid rock.

a. compaction - as sediments accumulate and become buried with time, the weight of overburden compact the sediment

(1) clay minerals are cohesive (sticky) and serve as a binding agent for sediment
(2) compaction also involves dehydration and hardening of sediment into rock

b. cementation - solutions carry ions into pours between sediments, with time ions may be precipitated as cements under appropriate chemical condition.

(1) Common cements include calcite, silica, and iron oxide.

C. Sedimentary Rock Types/Classification

Detrital vs. Chemical Sedimentary Rocks.

1. Detrital Sedimentary Rocks: "Detrital" = Fragmented Origin.

a. Composition: sediments composed of quartz, clay, feldspars, and associated array of just about any other mineral in lesser proportions (e.g. amphibole, or any of silicate/igneous minerals, as well as recycled sedimentary rocks).

(1) E.g. Granite is weathered - produces quartz, and feldspars, plus mica: quartz is most resistant mineral and as a result is most common remnant product.

(2) the composition of the original rock (ig., sed., met.) that is weathered will have a direct influence on the composition of the sediment/sed. rock that results.

b. Texture of Sediment - size, shape and arrangement of sediment grains in

the rock

(1) Sediment Size Classification (i.e. Average Diameters of Particles)

Sediment Size	Resulting Rock
Clay = < 1/512 mm = < 0.002 mm	Shale or Mudstone
Silt = 1/512 - 1/16 mm = 0.002 - 0.0625 mm	Siltstone
Sand = 1/16 - 2 mm = 0.0625 -2.0 mm	Sandstone
Gravel = >2.0 mm	Conglomerate / Breccia
Pebbles= 2.0 - 64 mm	
Cobbles = 64 - 256 mm	
Boulders = >256 mm	

(2) Grain Shape

(a) Angular vs. Rounded Grains
i) Rounded Grains = more transport / tumbling
(b) Spherical vs. Non-spherical Grains

(3) Grain Sorting

(a) Degree to which grains are same size

i) poorly sorted sediment - different sizes
ii) highly sorted sediment - same size

c. Detrital Rock Types (shale, sandstone, conglomerate)

(1) Shale - detrital sed. rock consisting of lithified clay and silt sized particles, very small particles < 1/16 mm (must use microscope to see particles),

(2) Sandstone - detrital sed. rock made up of sand sized grains.

(3) Conglomerate - lithified gravels (boulders, to pea sized sediment), often poorly sorted with finer sediment between gravel.

2. Chemical / Biochemical Sedimentary Rocks -

a. Processes
(1) Chemical sediments may be directly precipitated under high concentrations of ions in water (e.g. halite/rock salt), or
(2) ions may be "fixed" by organisms living in the water in shells, accumulation of shells may then provide material for chemical sedimentary rock.

b. Texture of Chemical Sedimentary Rocks
(1) Crystalline Texture
(a) sugary appearance, crystals visible to eye

(b) interlocking mineral crystals

(2) Microcrystalline Texture

(a) crystalls too small to see, need microscrope

c. Limestone - composed of a mosaic of the mineral calcite ($CaCO_3$) and forms by either chemical precipitation or biochemical processes. Biochemical processes account for 90% of the limestones.

d. Dolomite - similar to limestone, but has Mg incorporated into $CaCO_3$, $CaMgCO_3$.

e. Chert - SiO_2, microscrystalline silica deposited from solution in open ocean.

f. Evaporites - chemical sed. rock that result from precipitation of minerals via evaporation of water.

(1) E.g. halite/rock salt (NaCl) and Gypsum ($CaSO_4$). Commonly associated with shallow seas and brine lakes (e.g. Salt Lake).

g. Ironstone - composed of iron-bearing minerals (hematite, limonite)

h. Coal - carbon-based rock derived from plant material

(1) Bituminous coal - "soft coal", black

(2) Anthracite coal - "hard coal", brownish

(3) Lignite - "brown" immature coal

(4) Peat - brown / compressed plant debris

3. Other Terms

a. Clastic vs. nonclastic -

(1) clastic = fragmental. E.g. sandstone is a clastic detrital rock, fossiliferous limestone is a clastic chemical rock,

(2) non-clastic = massive, crystalline appearance; if limestone has no fossils evident, then would be considered non-clastic.

4. Sedimentary Rock Classification System

a. Detrital Rocks - distinguished mainly by grainsize and grain composition (mineralogy of grains)

(1) subdivided on basis of texture and composition

b. Chemical Rocks - distinguished mainly by composition of minerals (halite, gypsum, chert)

(1) subdivided on basis of chemical composition / mineralogy

c. Biochemical Rocks - fossil-based, made up of shells or skeletal fragments

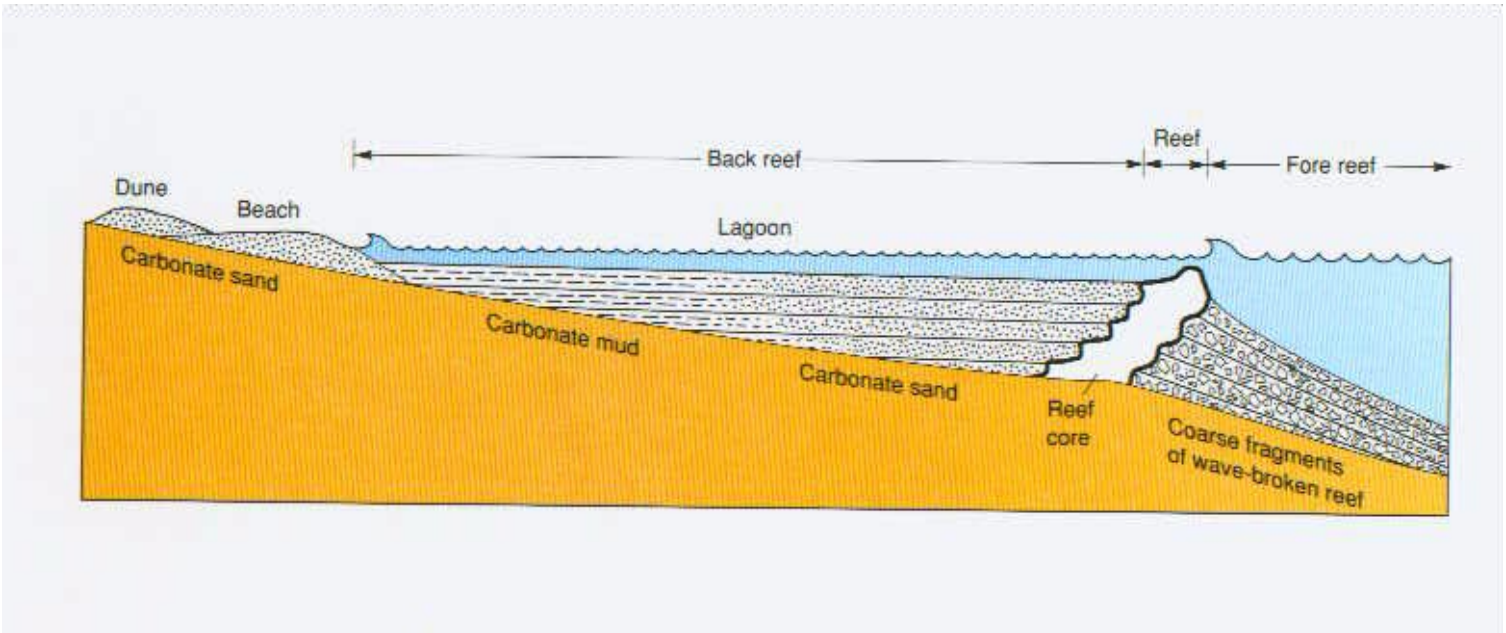
(1) subdivided on basis of grain size / crystallinity

Sediment Particles and Clastic Sedimentary Rocks

Diameter (mm)	Sediment		Sedimentary Rock
256	Boulder	Gravel	Conglomerate (rounded particles) or Breccia (angular particles)
64	Cobble		
2	Pebble		
1/16	Sand		**Sandstone**
1/256	Silt	"Mud"	**Shale,** Siltstone, or Mudstone
	Clay		

Sandstone and shale are quite common; the others are relatively rare.

Near-shore Marine Sedimentary Enviroments



Overview of Sedimentary Environments