Rocks: Material of the Solid Earth

I. The rock cycle
    A. Inter-relationship of parts of Earth system
        1. Three types
            a. Igneous—crystallized from magma
            b. Sedimentary—deposited by deposition or precipitation
            c. Metamorphic—changed in the solid state
II. Igneous rocks
    A. Magma
        1. created by partial melting of Earth material
            a. mostly silica—silicon-oxygen compound
            b. contains dissolved gases also—water, mostly
        2. rises toward surface because it is hot fluid containing gases
            a. at surface, it is lava, which has lost most of its dissolved gas
                1) volcanoes of Hawaii are BASALT—most common extrusive rock
                2) volcanoes of western Americas are ANDESITE
            b. most solidifies deep below surface as intrusive rock
                1) vast areas of mountain ranges are exposed intrusive rock
                2) Sierra Nevadas, Idaho Batholith, Pacific Coast Range, wide areas of Canadian Shield, core of southern Appalachians
            c. Ions in the 'melt' move freely to orderly locations in crystals
                1) Slow-cooling allows ions to travel to initial crystals, make larger over time
                2) Rapid cooling results in small inter-grown crystals
                3) Extreme cooling can quench magma to glass—no crystals
    B. Igneous textures—size, shape and arrangement of interlocking crystals
        1. fine-grained texture
            a. crystals to small to distinguish with the naked eye: < 1 mm
            b. implies rapid cooling, usually accomplished at Earth's surface
            c. may allow trapping of gas bubbles
                1) basalt commonly has vesicles,
                2) scoria has relatively more holes that are smaller, and does not have large crystals imbedded in fine-grained matrix
            d. BASALT is the most common fine-grained igneous rock
        2. coarse-grained texture
            a. crystals large enough to distinguish individual grains without magnification: > 1 mm (you may need magnification to ID)
            b. implies slow cooling, below surface
            c. GRANITE is the most common coarse-grained igneous rock
        3. porphyritic texture
            a. two distinct crystal sizes
            b. extrusive rocks will have PHENOCRYSTS in a fine-grained matrix
                1) implies initial slow cooling below surface

2) magma composed of crystals and melt is erupted, rapid cooling suspends large crystals in fine-grained matrix
c. Intrusive rocks may have change in cooling rate, resulting in large crystals imbedded in finer, but still coarse, grained matrix

4. glassy texture
a. extremely rapid cooling
b. no minerals formed
1) obsidian
2) pumice

C. chemical composition
1. Magma is mostly silica—silicon and oxygen
a. ‘low-silica’ magma is about half silica
b. ‘high-silica’ magma may be 70% or more
c. Other components include Al, Fe, Ca, Na, K, Mg
2. FELSIC magma is high in silica
a. Crystallizes into mostly feldspars and quartz, some muscovite
b. Light in color
c. Also have small amounts of dark minerals
d. Granite is coarse-grained, rhyolite is fine-grained
3. MAFIC magma has enough Fe, Mg to make ‘ferromagnesian’ minerals
a. Olivine, augite, hornblende, biotite
b. Dark in color
c. Magma formed at oceanic ridges is mafic, leading to basalt
d. Gabbro is coarse-grained mafic rock
4. Intermediate composition magmas form diorite and andesite
a. Not enough silica to form quartz
b. Commonly medium in color, or contrasting matrix and phenocrysts
c. Andesite is extrusive, diorite is intrusive

D. Formation of igneous rocks from magma
1. distinct sequence of crystallization
a. first olivine crystallizes (if there is enough Fe, Mg)
b. next pyroxene (Augite) and Ca-rich plagioclase feldspar
c. cooler forms amphibole (Hornblende) and Na-rich plagioclase
d. biotite before potassium feldspar (K-spar) and muscovite
e. quartz forms last
2. order of crystallization important in resulting texture and rock
a. intergrowth of crystals—
1) first formed better shaped
2) later-formed fill in spaces
b. solids can settle out,
1) resulting in rock that may not reflect original magma composition—ultramafic olivine-rich rock called peridotite
2) leaving magma enriched in silica, depleted in iron and magnesium

3. magma can melt and ‘assimilate’ surrounding rock, or two major types can combine, changing its chemistry toward intermediate

III. Mineral resources
   A. Reserves—profitable, identified deposits
   B. Ores—metallic minerals that can be mined at a profit
   C. Economic factors may change