I. Basic Definitions

A. Rock - an aggregate of one or more minerals, i.e. mineral crystals are bound together or lithfied into an aggregate or rock.

1. Rocks are composed of minerals (either many different minerals, or the same mineral)

B. Mineral - a naturally occurring inorganic solid, which possess a definite internal atomic structure, and a specific chemical composition.

1. Minerals = an inorganic chemical compound (2 or more elements bonded together)

C. Elements - all matter is made of elements, over 100 elements are known.

1. Elements are organized on the periodic table

D. Compounds - combination of two or more elements joined together at the atomic level.

E. Atom - the smallest recognized particle of matter that retains the properties of a given element. Atoms of elements are combined together to form compounds.

1. Atoms composed of...
   a. nucleus (protons + neutrons)
   b. orbiting electrons

2. Atoms of elements are defined by the number of protons

   a. e.g. all oxygen atoms possess 8 protons

II. Minerals and Basic Properties

A. Mineral - naturally occurring inorganic solid, consisting of atoms combined together as chemical compounds, possessing a definable internal structure.

1. Rocks are composed of 1 or more mineral crystals combined together as aggregates.

2. atoms---bonded----compounds/minerals----combined/lithified----rocks-----create structure of earth

B. Physical Properties of Minerals - the unique chemical/atomic composition of minerals and the crystalline arrangement of the atoms within the mineral structure give a particular mineral a defineable and recognizable set of physical properties.

1. Crystal Form of a mineral - the external expression of a mineral that reflects the orderly internal arrangement of atoms.

a. E.g. quartz crystals - if a mineral is allowed to form without space restrictions, it will develop individual xls with well developed crystal faces.

2. Luster - the appearance or quality of light reflected from the surface of a mineral.

a. E.g. metallic luster, submetallic, vs. non-metallic luster (includes glassy, pearly, silky, resinous, and dull)

3. Color - colors can be helpful in identifying a mineral, but is generally useful as minor impurities in a mineral can cause wide color variation (e.g. quartz comes in pink, purple, white, gray)

4. Streak - the color of a mineral in its powered form obtained by rubbing it across a porcelain plate. Streak color can be very different from the mineral color.

5. Hardness - resistance of a mineral to abrasion or scratching. Very diagnostic of a mineral. Mohs hardness scale developed as a frame of reference.

6. Cleavage - tendency of of a mineral to break along planes of weak atomic bonding. Different minerals have different types and directions of cleavage.

7. Fracture - minerals (e.g. quartz) do not have cleavage but instead break along uneven surfaces.

a. Conchoidal fractrue = breaks like glass.
b. Others may break into splinters or irregularly.

8. Specific Gravity - Ratio of the weight of a mineral relative to a similar volume of water.

a. E.g. if a 1 cm^3 piece of mineral weighs 3 x as much as 1 cm^3 of water, its s.g. = 3.

C. Mineral Groups (over 2000 minerals types known to exist, only about 24 are most abundant)

1. Rock Forming Minerals - those minerals that are the most abundantly found on the earth and that most commonly comprise rocks.

a. 8 Elements constitute 98% of the earth's crustal minerals

oxygen	46.6%
Silicon	27.7%
Aluminum	8.1%
Iron	5.0%
Calcium	3.6%

Sodium	2.8%
Potassium	2.5%
Magnesium	2.1%
Others	1.5%
Total	100%

2. Silicates- Most common mineral groups composed of silica and oxygen...known as the silicates

    a. composed primarily of silica and oxygen with subordinate amounts of other elements to maintain electrical neutrality on the subatomic level).

3. Carbonates - Ca, Mg and CO_3 - next common

4. Oxides - consist of metallic elements and oxygen

5. Sulfates and Phosphates (SO_4 and PO_4)

6. Halides - Cl-based minerals - e.g. "salt" NaCl

7. Native Elements - Au, Ag, and C (diamond).

8. e.g. of mineral uses, quartz = glass, calcite = cement, gypsum = plaster.

III. Rocks and the Rock Cycle

A. Three Rock Types (based on their mode of origin)

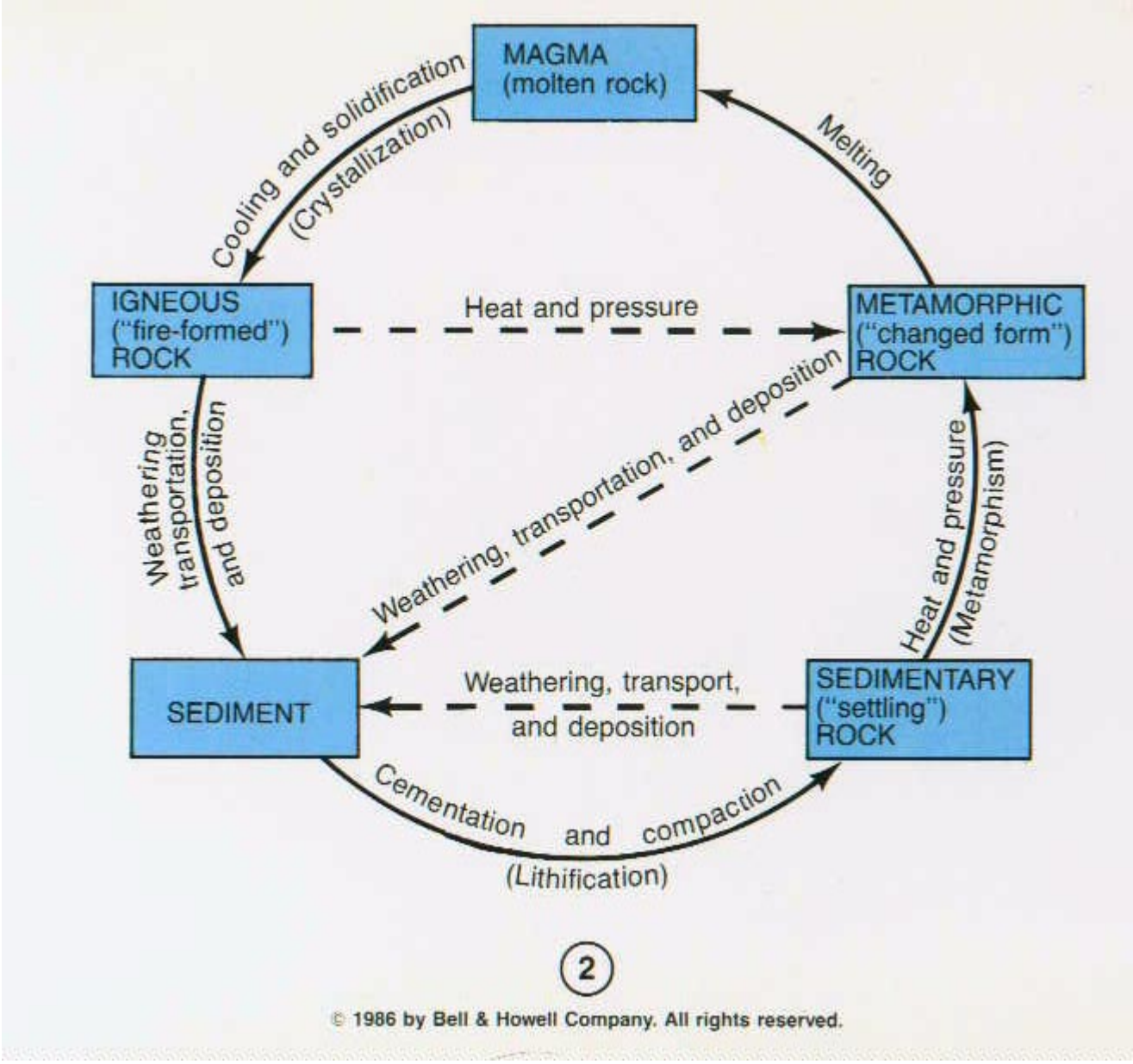
1. Igneous: rocks crystallize from molten magma
    a. Molten Rock from Earth's Interior
2. Sedimentary: rocks form at near earth's surface
    a. Water-related Rocks
3. Metamorphic: rocks formed by alteration of pre-existing rocks
    a. Rocks subject to re-heating and pressure

B. Igneous Rocks- a rock (or agglomeration of one or more minerals) that results from the cooling of magma, or molten rock.

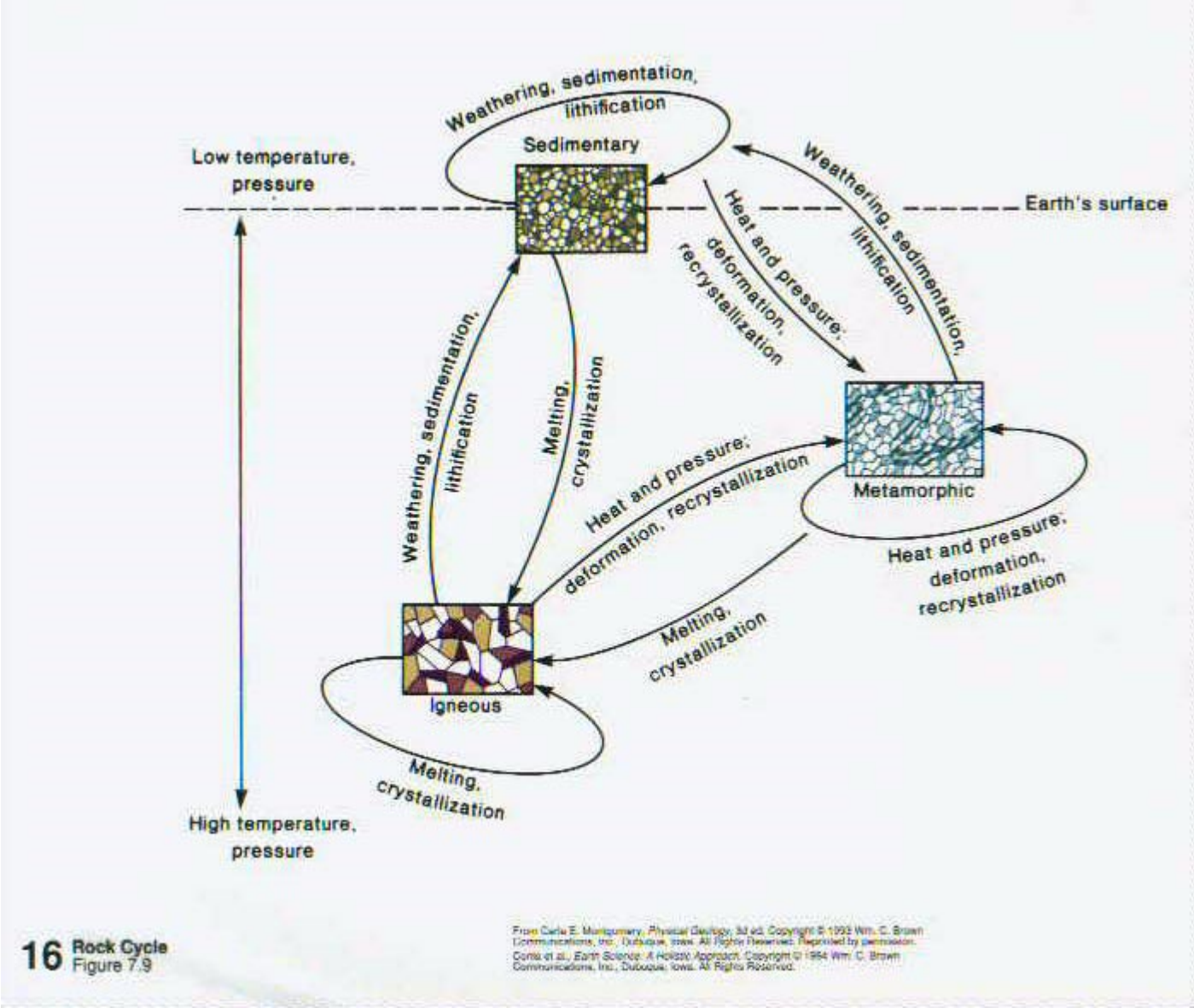
1. As the magma cools, minerals crystallize from the molten rock.
    a. Magma - molten or hot liquid rock, originates beneath the earth's surface (up to 120 miles beneath), composed of elements found in silicate minerals, water vapor, and gases.

    b. Lava - magma that is extruded onto the earth's surface via volcanic eruptions (hot magma is confined at depth beneath surface, relatively lighter than confining rock, rises upward, may eventually erupt onto earth surface).

Simplified Diagram of Rock Cycle



Rock Cycle - Expanded Version with Process Interactions Listed



16 Rock Cycle
Figure 7.9

c. Extrusive Igneous Rocks or Volcanic Ig. Rocks - rocks which solidify from lava (or were extruded onto earth's surface)

(1) Fast cooling tends to result in smaller mineral crystals

(2) Very rapid quenching = "glass"

d. Intrusive Igneous Rocks or Plutonic Ig. Rocks - rocks which solidify from magma beneath the earth's surface.

(1) Slow cooling tends to result in larger mineral crystals

C. Sedimentary Rocks

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

2. Steps in the formation of sedimentary rocks

Step 1 - weathering of pre-existing rocks at the Earth's surface (physical and chemical decomposition of rocks)

Step 2 - rock weathering produces "sediment" - soft, loose material that results from physical breakdown of pre-existing rocks (e.g. sand, gravel)

(chemical weathering results in dissolved elements in water)

Step 3 - transportation and deposition of sediment at the Earth's surface, as related to energy

Agents of Transportation: gravity, wind, water, ice

Step 4 - "lithification" of loose sediment into rock

(chemical cements and compaction transform loose sediment into hard sedimentary rocks)

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. Sedimentary Rock Record - the "tape recording of earth history"

a. Fossils are found in sedimentary rocks

b. Characteristics of sedimentary rocks record the environment of transportation and deposition at the Earth's surface

(1) Rock Interpretation = reconstruction of ancient sed. environments

(a) (e.g. river, shallow ocean, deep ocean, lagoon, lake, swamp).

(b) fossils, Earth history

c. Importance of Sedimentary Rocks

(1) Sedimentary rocks are where we find many natural resources such as coal and oil, also many ore minerals are found in sedimentary rock "hosts" (e.g. Uranium).

D. Metamorphic Rocks

1. Metamorphic Rocks: Pre-existing sedimentary and/or igneous rocks may be subject to reheating or great pressures during mountain building and will react and recombine to form metamorphic rocks

2. Basic Terminology/Definitions:

a. Process of metamorphism involves transformation of pre-existing rock (ig. sed. or even met.) under temperature and/or pressure. Result in change in both composition/mineralogy; and texture of rock as well.

b. The "grade" or degree of metamorphism ranges from slight (low grade) e.g. >compaction; to very intense (high grade) where original mineral components can no longer be recognized.

c. Under conditions of heat and pressure, rocks will begin to deform "plastically", bend, minerals may partially melt and recrystallize into different forms. Rocks can deform and become folded in process of metamorphism.

(1) Metamorphic may be in turn heated to the point of re-melting to form magma and igneous rocks.

3. Textural and Mineralogical Changes- under temps. and press. of metamorphism, pre-existing rocks may under go changes in mineralogy during the recrystallization process or may also have textures realigned

a. Foliation - color banding or mineral alignment in a metamorphic that results from pressure during metamorphism.
(1) e.g. gneiss.

b. Non-foliated texture- no banding is visible, common in rocks composed of one mineral of similar color and crystal size (e.g. limestone to marble)

4. Common Metamorphic rock types

a. Foliated or Layered Metamorphic Rocks

(1) Slate- finely crystalline foliated rock composed of microscopic mica flakes, excellent rock cleavage into thin flat slabs. Slate results from low grade metamorphism of shale.

(2) Gneiss - foliated metamorphic rocks with color banding. White bands = quartz and feldspar, dark bands = ferromagnesian minerals.

5. Non-foliated Metamorphic Rocks

a. Marble - coarse, crystalline rock whose parent rock was limestone or dolomite, when pure is white and composed of calcite, relatively soft used for carving

b. Quartzite - non-foliated metamorphic rock resulting from met. of sandstone, quartz grains fuse under moderate to high grade metamorphism

IV. ROCK CYCLE

A. Full cycle: magma-----cooling/crystallization---igneous rocks---weathering----sediment---lithification/compaction----sedimentary rocks---pressure and temperature----metamorphism----metamorphic rocks----remelting-----igneous rocks