Name_____

89.325 Geology for Engineers
Rocks

I. Introduction

The bulk of the earth's crust is composed of relatively few minerals. These can be mixed together, however, to give an endless variety of rocks - aggregates of minerals, rock fragments and glass. All rocks are classified on the basis of their mineral content (or other components if minerals are not present) and texture. The system of classification and the textural terminology are different, however, for the three groups (igneous, metamorphic, sedimentary) of rocks. It is therefore important to determine the rock group before attempting to classify a rock.

II. Classification into rock groups

Rocks can be assigned to one of the three groups by considering the following characteristics of each rock group:

Igneous. Igneous rocks have solidified from molten matter (magma) and are composed of individual, interlocking crystals. If solidification occurred very rapidly the rock may be glassy, contain glass shards, or be filled with holes (vesicles) which are formed when gas escapes from the magma.

Sedimentary. Sedimentary rocks are composed of particles derived from pre-existing rocks, or materials precipitated from solution, or organic matter. In the field sedimentary rocks show distinct layering which may not be apparent in small hand specimens. Sedimentary rocks are composed of individual grains cemented together. Fossils are almost exclusively restricted to sedimentary rocks.

Metamorphic. Metamorphic rocks are derived from previously existing rocks in response to changes in pressure, temperature and fluid content. These process change the mineral composition and/or texture of the pre-existing rock. In general, metamorphic rocks have a banded or foliated appearance (foliated - appear to be composed of thin layers pressed together). If the rock is composed of one mineral it may have a blocky appearance and be composed of large crystals that are densely intergrown.

III. Igneous rocks

Igneous rocks are classified on the basis of their texture and mineral composition.

Textural terms:

1. Pegmatitic - grains greater than 1.2 cm in diameter.
2. Phaneritic - grains can be seen with the unaided eye.
3. Aphanitic - grains cannot be seen with the unaided eye (i.e. you need a hand lens or microscope).
4. Porphyritic-phaneritic - two distinct grain sizes. Smaller grains can be seen with the unaided eye.
5. Porphyritic-aphanitic - two distinct grain sizes. Smaller grains cannot be seen with the unaided eye.
6. Amygdaloidal - vesicles in aphanitic rock filled with a mineral.
7. Glassy - rock looks like a glass. No crystalline structure. Example - obsidian.

8. Scoriaceous - many holes (vesicles) found in the rock. Frothy appearance. Examples – pumice (usually light colored), scoria (usually red or black in color).
9. Fragmental - rock composed of angular fragments. Example - igneous breccia

Identification of common minerals in igneous rocks:

1. Quartz - smokey appearance, vitreous luster, hardness of 7, no cleavage.
2. Orthoclase feldspar - light in color, two right angle cleavages, hardness of 6.
3. Plagioclase feldspar - light to dark in color, two right angle cleavages, hardness of 6.
4. Muscovite - cleavage results in flakes, light in color.
5. Biotite - cleavage results in flakes, dark in color.
6. Hornblende - dark green in color, splintry, elongate, 60^{o} - 120^{o} cleavage angle.
7. Augite - black in color, hard, poor cleavage, 90^{o} - 90^{o} cleavage.
8. Olivine - green in color, granular appearance.

A generalized classification scheme for the igneous rocks is given in Figure 1. Note that scoria does not appear in Figure 1, but you may want to use this rock name when you classify your unknowns. **Scoria** is a highly vesicular, dark colored (brown, black, or red) volcanic rock that may or may not contain crystals (phenocrysts).

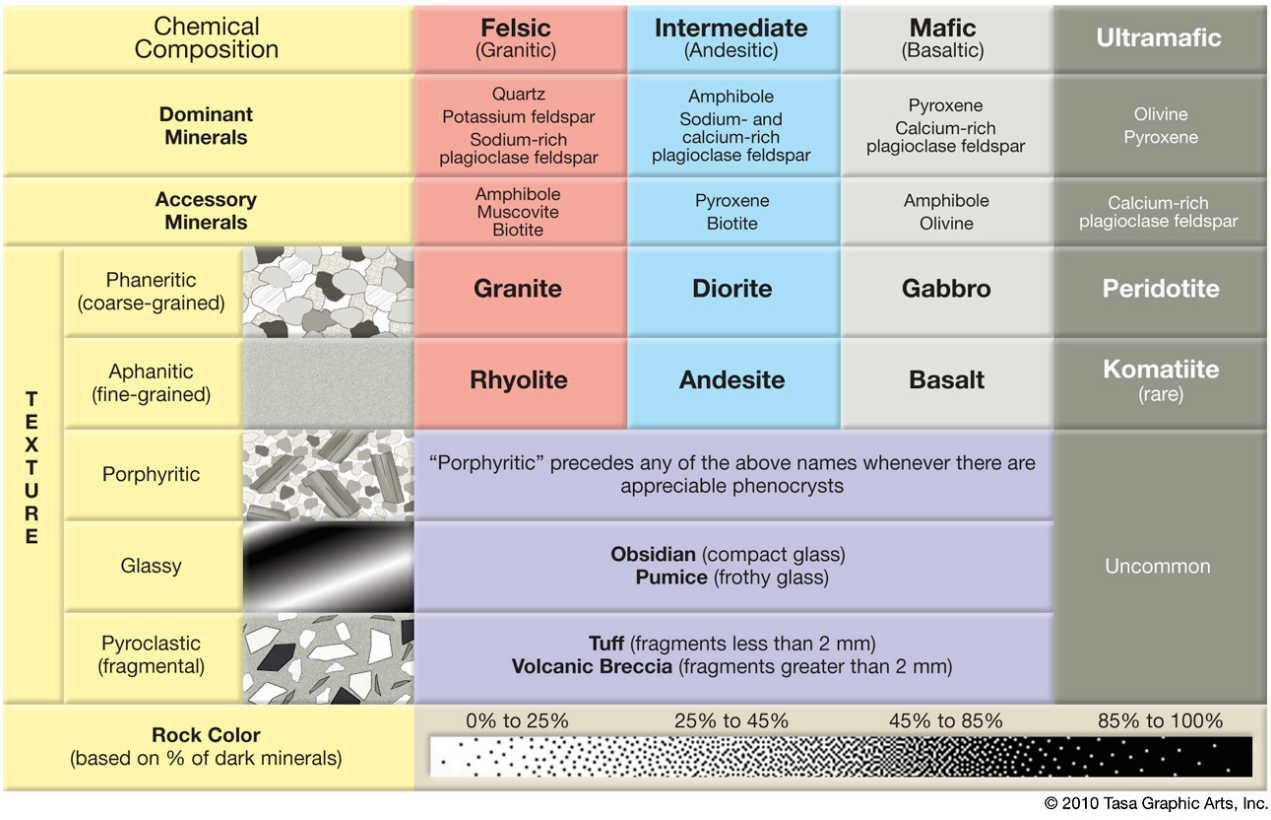

Figure 1. Igneous rock classification scheme

IV. Sedimentary rocks

Sedimentary rocks can be broadly divided into three groups:

1. Clastic - formed from the accumulation of mineral and rock fragments.
    - Breccia - large angular fragments
    - Conglomerate - large rounded fragments, pebbles
    - Sandstone - composed of sand sized particles
    - Shale - composed of mud sized particles, has fissility, a dull thud when struck
    - Tillite - composed of all sizes of particles from silt to large fragments, glacial origin

2. Organic and biochemical - rocks produced from organic remains or minerals formed by organisms.
    - Limestone - composed of calcite or aragonite
        - Lithographic - extremely fine grained
        - Fossiliferous - contains shell fragments
        - Coquina - poorly cemented shell fragments
        - Chalk - accumulation of skeletons of one-celled animals that secrete calcareous shells
        - Dolomite - composed of dolomite
        - Siliceous - composed of silica
        - Flint - black in color, hard
        - Chert - light in color, hard
    - Carbonaceous - composed predominately of organic material
        - Peat - loose and porous accumulation of organic matter
        - Lignite - a brown coal with a fibrous woody structure
        - Bituminous coal - soft coal, dull black in color
        - Anthracite coal - hard coal, shiny black in color
        - Bog iron ore - composed of hydrated iron oxide (goethite)

3. Chemical precipitates - rocks formed by precipitation of crystalline material from solution. Examples are gypsum and rock salt.

A generalized classification scheme for the sedimentary rocks is given in Figure 2.

V. Metamorphic rocks

Metamorphic rocks are divided into two groups based on the presence or absence of foliation. Foliation varies from very fine to coarse foliation (mica flakes clearly visible) to gneissic textures in which the minerals are segregated into layers. A simplified classification scheme for the metamorphic rocks is given in Figure 3.

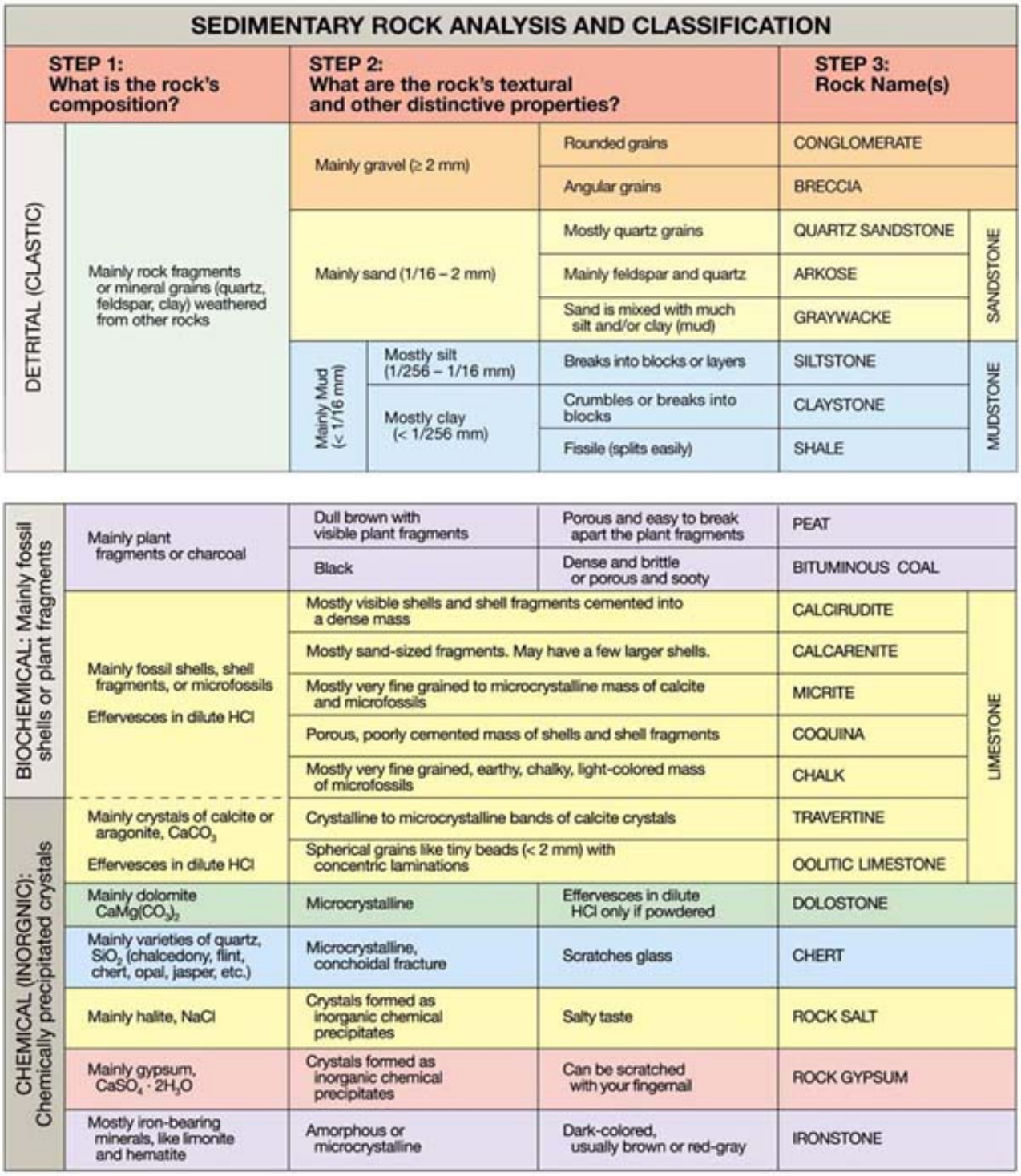

Figure 2. Sedimentary rock classification scheme.

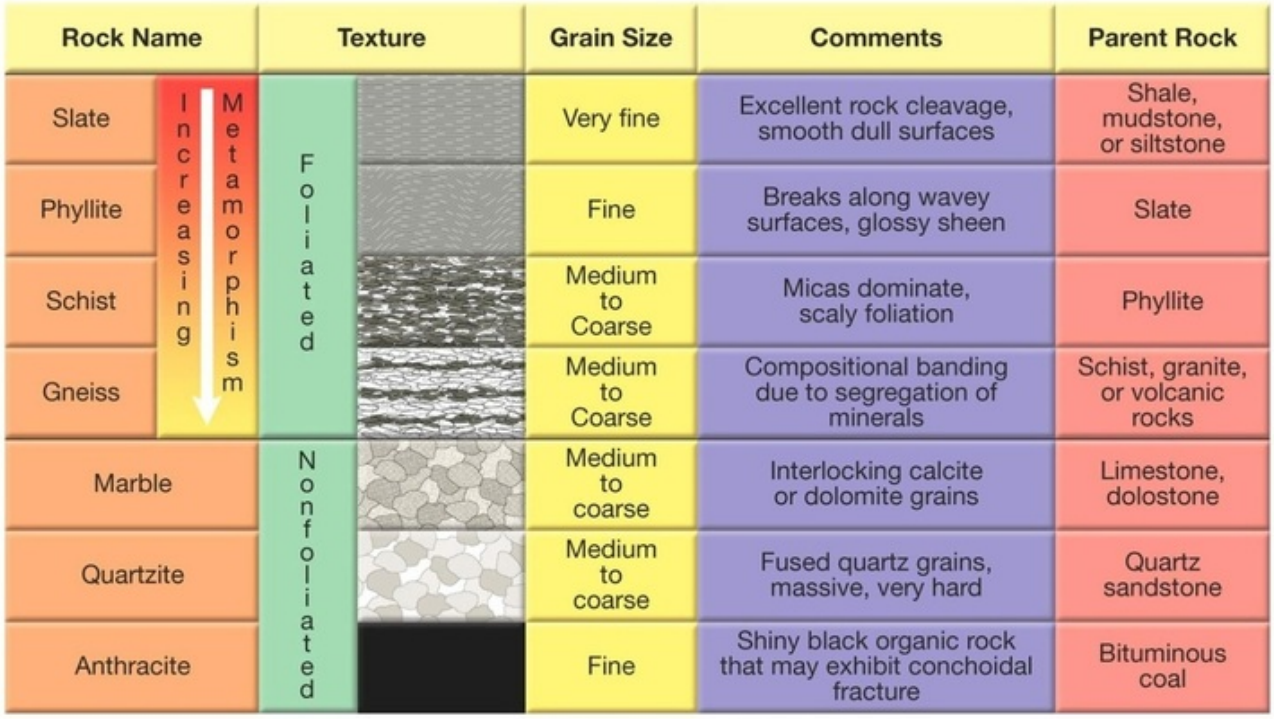

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Figure 3. Classification scheme for the metamorphic rocks

VI. Classification of unknown rock specimens

Separate your unknowns into igneous, sedimentary and metamorphic groups. The instructor will check your groupings. Identify the rocks within each group using texture and mineralogy. Enter the rock name and its characteristics on the data sheet (next page).

Data Table for Rock Identification Exercise

Rock Name	Texture	Components
Igneous Rocks		
Metamorphic Rocks		
Sedimentary Rocks		

VII. Rocks and engineering applications

1. You are designing a road cut for an interstate highway. You have been given samples of the local rock.

   a. Identify the rocks (A-1 and B-79)

   b. In designing the road cut, how will the rock type affect your design criteria?

2. You are asked to select the facing stone for a building to be erected in downtown Boston. The contractor suggests two different rocks.

   a. Identify the rocks (C-173 and D-45)

   b. Which rock would you select for the facing stone and why?

3. You are constructing a small office building in Lowell, Massachusetts. Two different rocks (bedrock) are exposed on the site.

   a. Identify the rocks (E-52 and F-190)

   b. Which bedrock would be the better choice for the building foundation and why?

4. You are building a new bridge and need aggregate for the bridge abutments. Local stone will be used.

   a. Identify the two local rock types (G-97 and H-231)

   b. Which would you select for the aggregate and why?

5. You are driving a road tunnel. During the course of the tunneling operation you encounter two different rock types.

   a. Identify the rocks (I-31 and J-246)

   b. Which rock will be easier to tunnel through and why?

   c. Considering the two rock types, will the tunnel opening need to be supported? Explain.