ROCK IDENTIFICATION

I. Introduction

There are three basic types of rocks - igneous, sedimentary, and metamorphic:

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) that 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.

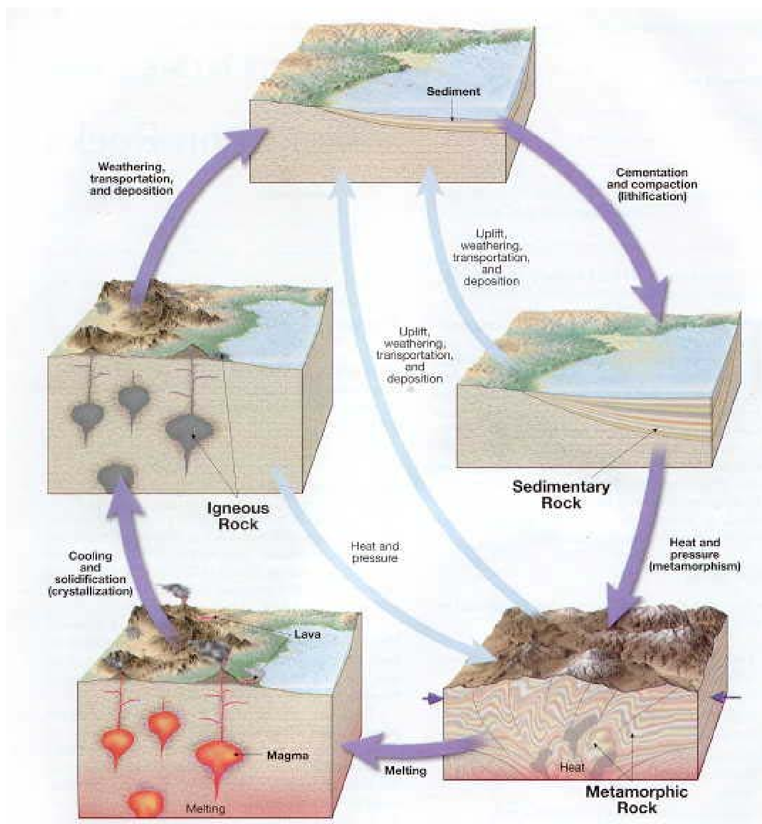


Figure 1. The rock cycle illustrates the role of various geologic processes in the formation of rocks. From Tarbuck. Lutgens, and Pinzke (2003).

The formation of the various groups of rocks can be illustrated using the rock cycle (Fig. 1). The cycle starts with the formation of igneous rocks by the solidification of molten silicate melts (magmas). Note that these melts can form in the crust of the earth or deeper in the earth (mantle). The magmas ascend to higher levels where they either solidify below the surface forming plutonic rocks or reach the surface forming volcanic rocks. Weathering and erosion of the igneous rocks (note that metamorphic and sedimentary rocks are also eroded if they’re at the surface) produces sediments that are transported by wind and water. These sediments are converted to sedimentary rocks by compaction and cementation (lithification). Increases in temperature and pressure change the texture and/or mineralogy of the rocks producing metamorphic rocks. In certain cases metamorphic rocks can melt to produce magmas, but in most cases regional uplift and erosion results in the metamorphic rocks being once again converted to sediment.

The earth is a very dynamic body and rock material is continually recycled. Plate tectonics is the description of this dynamic process. New material rising from deep in the mantle of the earth is added to the crust of the earth along mid-ocean ridge systems and crust is returned to the mantle at subduction zones. Where this subduction process occurs we find volcanoes such as along the margins of the Pacific Ocean. The continents are passive members of the large plates that make up the surface of the earth. Where continents collide, such as the present day collision between the Indian subcontinent and Asia large mountain ranges are formed. It is these dynamic processes that are responsible for the formation of igneous, sedimentary, and metamorphic rocks. In areas of crustal thickening, such as the Himalayas, rocks from deep in the earth are brought to the surface by erosion. Thus we can see rocks at the surface that were formed deep in the earth. Consider this the next time you are in New Hampshire where we have rocks now exposed at the surface which were once 15 to 20 km (9 to 12 miles) below earth's surface. These are metamorphic rocks that formed when present-day North America and Europe collided during an earlier plate tectonic cycle. Because of plate tectonics and other geologic processes the types of rocks that we find at the earth's surface vary from place to place.

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. Igneous rocks

Igneous rocks are classified on the basis of their texture and mineral composition (Fig. 2).

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 - two distinct grain sizes.
5. Glassy - rock looks like a glass. No crystalline structure. Example - obsidian.
6. Scoriaceous - many holes (vesicles) found in the rock. Frothy appearance. Examples - pumice (usually light colored), scoria (usually red or black in color).
7. 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.

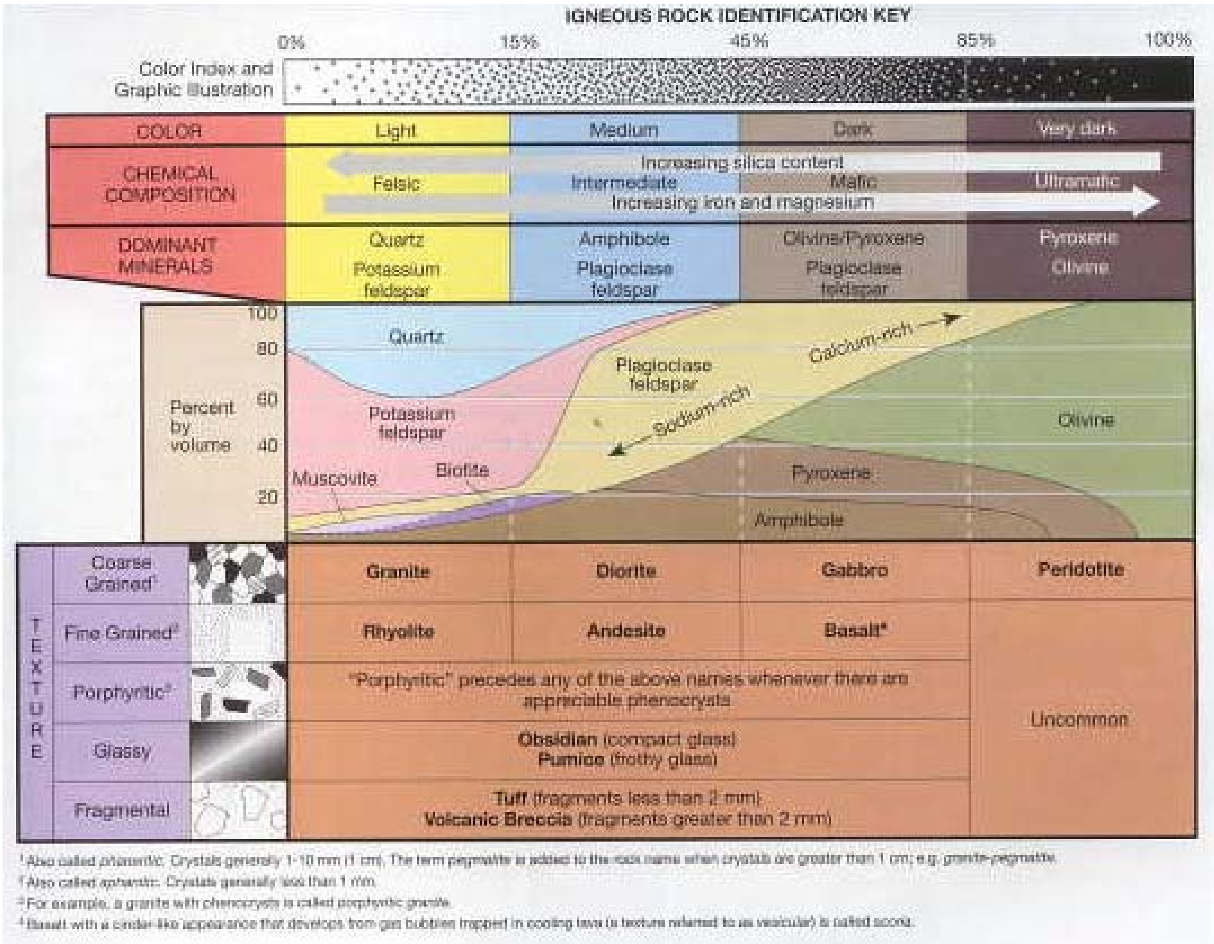


Figure 2. Igneous rock identification key. Color, with associated mineral composition, is shown along the top axis. Each rock in a column has the color and composition indicated at the top of the column. Texture is shown along the left side of the key. Each rock in a row has the texture indicated for that row. To determine the name of a rock, find the intersection between the appropriate column (color and mineral composition) and the appropriate row (texture) and read the name at the place of intersection. From Tarbuck, Lutgens, and Pinzke (2003).

III. Sedimentary rocks

Sedimentary rocks can be broadly divided into two groups:

1. ***Detrital*** - formed from the accumulation of mineral and rock fragments.
   Breccia - large angular fragments
   Conglomerate - large rounded fragments, pebbles
   Sandstone - composed of sand sized particles
   Siltstone - composed of silt sized particles
   Shale - composed of mud sized particles, has fissility, a dull thud when struck

2. **Chemical** - rocks produced from organic remains or minerals formed by organisms and the precipitation of crystalline material from solution

A simplified classification scheme for the sedimentary rocks in given in Figure 3.

DETRITAL ROCKS

Texture (grain size)	Composition	Rock Name
Coarse (over 2 mm) with large grains	Rounded fragments of quartz and/or chert	**Conglomerate**
	Angular fragments of quartz and/or chert	**Breccia**
Medium (1/16 to 2 mm) feels "sandy"	Quartz usually dominates (If abundant feldspar is present the rock is called **Arkose**)	**Sandstone**
Fine (1/16 to 1/256 mm)	Quartz and clay	**Siltstone**
Very fine (less than 1/256 mm)	Quartz and clay	**Shale**

CHEMICAL ROCKS

Composition	Texture (grain size)	Rock Name		
Calcite, $CaCO_3$ (will effervesce)	Fine to coarse crystalline	**Crystalline Limestone**		Limestone
	Visible shells and shell fragments loosely cemented	**Coquina**	Biochemical	Limestone
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	Biochemical	Limestone
	Microscopic shells and clay	**Chalk**	Biochemical	Limestone
Dolomite $CaMg(CO_3)_2$ (will effervesce if powdered)	Fine to coarse crystalline	**Dolostone**		
Quartz, SiO_2	Very fine crystalline	**Chert (light colored) Flint (dark colored)**		
Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	**Rock Gypsum**		
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**		
Altered plant fragments	Various size fragments	**Bituminous Coal**		

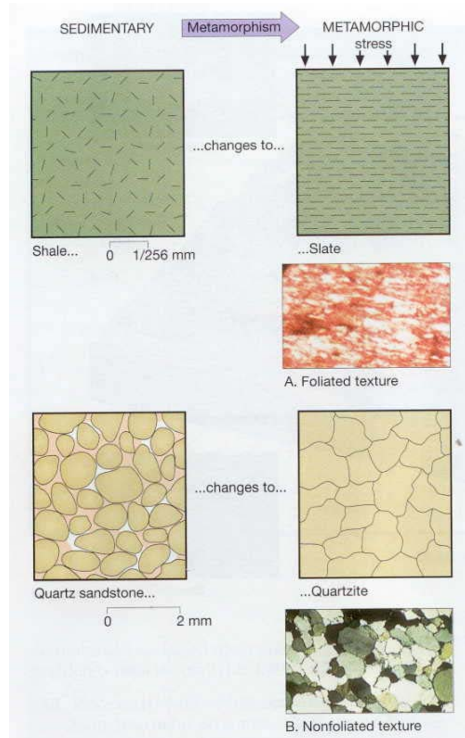
Figure 3. Sedimentary rocks are divided into two groups, detrital and chemical, depending upon the type of material that composes them. Detrital rocks are further subdivided by the size of their grains, while the subdivision of the chemical rocks is determined by composition. From Tarbuck, Lutgens, and Pinzke (2003).

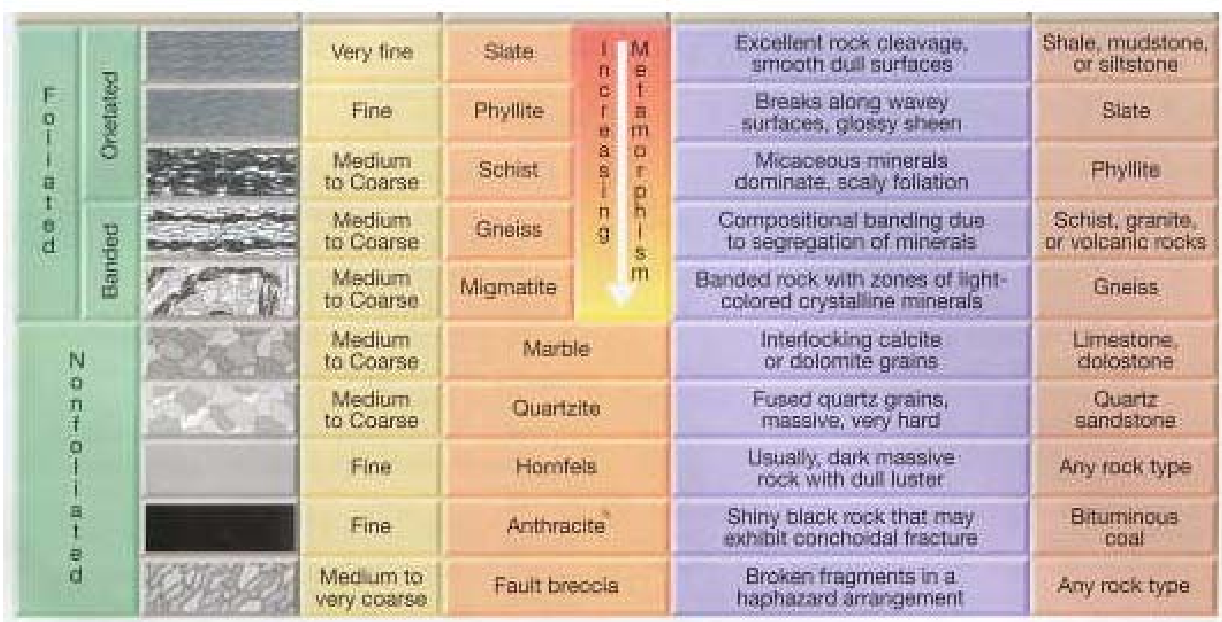
IV. Metamorphic rocks

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 (Fig. 4). Foliated metamorphic rocks are indicative of *regional metamorphism* - rocks over a broad area have been subjected to elevated pressures and temperatures. The length of time the rocks are subjected to these elevated pressures and temperatures determines the grain size of the rock, i.e. gneisses represent a longer period of time at high pressures and temperatures. Nonfoliated metamorphic rocks typically are the result of high temperature, but low pressure, metamorphism. These types of rocks often form in the contact zone between and igneous intrusion and the surrounding country rock. This type of metamorphism is referred to as *contact metamorphism*.

A simplified classification scheme for the metamorphic rocks is given in Figure 5.

Figure 4. Metamorphic rock textures. **A.** foliated textures result when elongated mineral crystals are aligned in a parallel, linear arrangement perpendicular to the compressional force. **B.** When crystals are not elongated the result is a nonfoliated texture consisting of interlocking mineral grains. From Tarbuck, Lutgens, and Pinzke (2003).





		Grain size	Rock name		Comments	Parent rock
Foliated	Orietated	Very fine	Slate	Increasing Metamorphism	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
Foliated	Orietated	Fine	Phyllite		Breaks along wavey surfaces, glossy sheen	Slate
Foliated	Orietated	Medium to Coarse	Schist		Micaceous minerals dominate, scaly foliation	Phyllite
Foliated	Banded	Medium to Coarse	Gneiss		Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
Foliated	Banded	Medium to Coarse	Migmatite		Banded rock with zones of light-colored crystalline minerals	Gneiss
Nonfoliated		Medium to Coarse	Marble		Interlocking calcite or dolomite grains	Limestone, dolostone
Nonfoliated		Medium to Coarse	Quartzite		Fused quartz grains, massive, very hard	Quartz sandstone
Nonfoliated		Fine	Hornfels		Usually, dark massive rock with dull luster	Any rock type
Nonfoliated		Fine	Anthracite		Shiny black rock that may exhibit conchoidal fracture	Bituminous coal
Nonfoliated		Medium to very coarse	Fault breccia		Broken fragments in a haphazard arrangement	Any rock type

Figure 5. Metamorphic rocks are divided into two textural groups, foliated and nonfoliated. Foliated rocks are further subdivided based on the size of the mineral grains. From Tarbuck, Lutgens, and Pinzke (2003)

NAME____________________

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.

DATA TABLE FOR ROCK IDENTIFICATION EXERCISE

Rock Group	Rock Name	Texture	Components